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TRANSMITTAL FORM		**Application Number**	**09/965,162**
(to be used for all correspondence after initial filing)		**Filing Date**	**September 27, 2001**
		First Named Inventor	**Steve E. Hoffman**
		Group Art Unit	**3724**
		Examiner Name	**Alie, Ghassen**
Total Number of Pages in This Submission	51	**Attorney Docket Number**	**9436-9US1 (147359)**

ENCLOSURES (*check all that apply*)

☐ Fee Transmittal Form	☐ Assignment Papers (*for an Application*)	☐ After Allowance Communication to TC
☐ Fee Attached	☐ Drawing(s) – Figs.	☒ Appeal Communication to Board of Appeals and Interferences Substitute Appeal Brief
☐ Amendment/Reply	☐ Licensing-related Papers	☐ Appeal Communication to TC (*Appeal Notice, Brief, Reply Brief*)
☐ After Final	☐ Petition	☐ Proprietary Information
☐ Affidavits/declaration(s)	☐ Petition to Convert to a Provisional Application	☐ Status Letter
☐ Extension of Time Request	☐ Power of Attorney, Revocation Change of Correspondence Address	☐ Other Enclosure(s) (*please identify below*):
☐ Express Abandonment Request	☐ Terminal Disclaimer	
☐ Information Disclosure Statement	☐ Request for Refund	
☐ Certified Copy of Priority Document(s)	☐ CD, Number of CD(s)	
☐ Response to Missing Parts/ Incomplete Application	☐ Landscape Table on CD	
☐ Response to Missing Parts under 37 CFR 1.52 or 1.53	**Remarks:**	

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	**Drinker Biddle & Reath LLP**
Signature	[signature]
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Date	December 11, 2006

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PHIP\532230\1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of Steve E. Hoffman

Serial No.: 09/965,162

Filed: September 27, 2001

For: IMPROVED SAW BLADE

Group Art Unit: 3724

Examiner: Alie, Ghassen

Attorney Docket No.: 9436-9US1 (147359)

Commissioner for Patents
P.O. Box 1450
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Mail Stop: Appeal Brief - Patents

SUBSTITUTE APPEAL BRIEF

Sir:

This Substitute Appeal Brief is being submitted in response to the Order Returning Undocketed Appeal to Examiner mailed on November 22, 2006 in regard to the above-identified application. This Substitute Appeal Brief has been prepared in compliance with the rules under 37 C.F.R. § 41.37(c). No time period was set for submitting this Substitute Appeal Brief. However, 37 C.F.R. § 41.37(c) permits submission of this Substitute Appeal Brief.

No fee is believe to be due for filing this Substitute Appeal Brief. If a fee is determined to be due, please charge such fee, and credit any overcharge, to Deposit Account 50-0573.

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BY Laura M. McNulty

DATE: December 11, 2006

1. Real Party in Interest

The instant application has been assigned to Mikronite Technologies Group, Inc. Mikronite Technologies Group, Inc. is the real party in interest for this application.

2. RELATED APPEALS AND INTERFERENCES

There are no appeals or interferences currently pending that are related to the instant application.

3. STATUS OF CLAIMS

Claims 1-6 and 13-19 are currently pending in this application. Claims 7-12 were cancelled pursuant to a restriction requirement and are no longer pending in this application. Claims 1-6 and 13-31 were rejected in a non-final office action mailed from the United States Patent and Trademark Office on April 20, 2005. Claims 20-31 were canceled by an amendment filed on July 20, 2005. A final rejection was mailed on August 18, 2005.

Independent claim 1 and its dependent claims 2-6, independent claim 13 and its dependent claims 14-18, and independent claim 19, as presented, have been twice rejected. This appeal is from the rejection of claims 1-6 and 13-19. The Claims Appendix includes claims 1-6 and 13-19 as rejected.

4. STATUS OF AMENDMENTS

Claims 1 and 13 (twice amended) and claim 19 (added by amendment on May 6, 2004) stand in the form in which they appeared in the Response to Office Action filed on May 6, 2004 concurrently with a Request for Continued Examination. Claims 2-6 (dependent from claim 1) and claims 14-18 (dependent from claim 13) stand in the form originally filed on September 27, 2001.

Claims 20-31 were canceled by in a Response filed on July 20, 2005.

5. SUMMARY OF CLAIMED SUBJECT MATTER

The claimed subject matter to be argued on appeal is in regard to independent claims 1, 13, and 19, and dependent claims 3 (dependent from claim 1) and 15 (dependent from claim 13). In addition, particular arguments are presented as to claims 2 and 14. Accordingly, claims 1-3, 13-15, and 19 are summarized below. Reference is made to the pages of the application as originally filed.

As recited in claim 1, the present invention provides an improved saw blade comprising a blade portion having two opposed sides which define a blade portion width (Page 3, lines 5-7). A cutting edge is formed on the blade portion, the cutting edge having a cutting tip width (Page 3, lines 13-15; Page 5, lines 16-21; Page 5, line 28 – Page 6, line 4; Figs. 1A, 1B, 2A, 2B). The side surfaces of the blade portion have a high precision surface finish of less than approximately 10 Ra (Page 3, lines 9-10; Page 6, lines 7-8). The surface finishing process additionally induces a reduced tensile stress on the surface of the blade which results in a structurally different blade than would otherwise exist (Page 10, lines 3-9). Testing has shown that a saw blade made in accordance with the present process is less susceptible to cracking than a conventional untreated saw blade (Page 6, lines 15-21). The high precision surface finish of the blade portion is formed by a high speed centrifugal polishing process (Page 3, lines 18-19; Page 10, lines 7-9; Figs. 3-5). The process comprises: providing a high speed centrifugal finishing apparatus having an outer vessel and at least one inner vessel (Page 7, line 19 – Page 8, line 10), placing the saw blade in the inner vessel (Page 8, line 23 – Page 9, line 4), adding abrasive finishing media into the inner vessel (Page 9, lines 5-8), and rotating the inner vessel at high speed relative to the outer vessel, the high speed rotation causing the abrasive media to surface finish the blades (Page 8, lines 4-22; Page 10, lines 7-9). The process is described in detail in U.S. Patent Nos. 5,140,783, 5,507,685, and 5,848,919 which are incorporated by reference in their entirety (Page 7, lines 16-18; Page 8, lines 16-22).

As recited in claim 2, the invention may comprise a straight saw blade (Page 5, lines 26-28; Page 11, lines 14-17). The width of the blade portion may be substantially the same as the width of the cutting tip (Page 3, lines 12-14; Page 6, lines 16-19). Due to the low friction surface finish provided by the present invention, the cutting edges need not be wider than the blade, a

feature distinguishing the present blade from conventional saw blades (Page 6, lines 19-24; Figs. 1A, 1B, 2A, 2B).

As recited in claim 3, the present invention may comprise a circular saw blade (Page 5, lines 26-28; Fig. 7). The circular saw blade includes an anti-kickback portion located circumferentially behind each cutting tip (Page 10, lines 22-27; Fig. 7). At least a portion of the sides of the anti-kickback portion may be finished with a low friction surface due to the high precision polishing (Page 11, lines 1-13).

As recited in claim 13, the present invention provides an improved saw blade comprising a blade portion having two opposed sides which define a blade portion width (Page 3, lines 5-7). A plurality of teeth are formed on the blade portion, the teeth having opposed sides, the teeth having cutting tips formed thereon which have a width (Page 3, lines 5-7; Page 5, lines 18-21; Page 5, line 28 –Page 6, line 2; Page 6, lines 16-22; Figs. 1A, 1B, 2A, 2B, 7). The side surfaces of the teeth have a high precision surface finish of less than approximately 10 Ra (Page 3, lines 9-11; Page 6, lines 7-8; Page 6, lines 19-22; Page 7, lines 11-15). The surface finishing process additionally induces a reduced tensile stress on the surface of the blade which results in a structurally different blade than would otherwise exist (Page 10, lines 3-9, 12-14). Testing has shown that a saw blade made in accordance with the present process is less susceptible to cracking than a conventional untreated saw blade (Page 6, lines 15-21). The high precision surface finish of the blade portion is formed by a high speed centrifugal polishing process (Page 3, lines 18-19; Page 10, lines 7-9; Figs. 3-5). The process comprises: providing a high speed centrifugal finishing apparatus having an outer vessel and at least one inner vessel (Page 7, line 19 – Page 8, line 10), placing the saw blade in the inner vessel (Page 8, line 23 – Page 9, line 4), adding abrasive finishing media into the inner vessel (Page 9, lines 5-8), and rotating the inner vessel at high speed relative to the outer vessel, the high speed rotation causing the abrasive media to surface finish the blades (Page 8, lines 4-22; Page 10, lines 7-9). The process is described in detail in U.S. Patent Nos. 5,140,783, 5,507,685, and 5,848,919, which are incorporated by reference in their entirety (Page 7, lines 16-18; Page 8, lines 16-22).

As recited in claim 14, the invention may comprise a straight saw blade (Page 5, lines 26-28; Page 11, lines 14-17). The width of the blade portion may be substantially the same as the width of the cutting tip (Page 3, lines 12-14; Page 6, lines 16-19). Due to the low friction surface

finish provided by the present invention, the cutting edges need not be wider than the blade, a feature distinguishing the present blade from conventional saw blades (Page 6, lines 19-24; Figs. 1A, 1B, 2A, 2B).

As recited in claim 15, the present invention may comprise a circular saw blade (Page 5, lines 26-28; Fig. 7). The circular saw blade includes an anti-kickback portion located circumferentially behind each cutting tip (Page 10, lines 22-27; Fig. 7). At least a portion of the sides of the anti-kickback portion may be finished with a low friction surface due to the high precision polishing (Page 11, lines 1-13).

As recited in claim 19, the present invention provides an improved saw blade comprising a blade portion having two opposed sides which define a blade portion width (Page 3, lines 5-7). A plurality of teeth are formed on the blade portion, the teeth having opposed sides, the teeth having cutting tips attached to the teeth which have a width (Page 3, lines 5-7; Page 5, lines 18-21; Page 5, line 28 –Page 6, line 2; Page 6, lines 16-22; Figs. 1A, 1B, 2A, 2B, 7). The side surfaces of the teeth have a high precision surface finish of less than approximately 10 Ra (Page 3, lines 9-11; Page 6, lines 7-8; Page 6, lines 19-22; Page 7, lines 11-15). The surface finishing process additionally induces a residual compressive stress on the surface of the blade which results in a structurally different blade than would otherwise exist (Page 10, lines 3-9). Testing has shown that a saw blade made in accordance with the present process is less susceptible to cracking than a conventional untreated saw blade (Page 6, lines 15-21). The high precision surface finish of the blade portion is formed by a high speed centrifugal polishing process (Page 3, lines 18-19; Page 10, lines 7-9; Figs. 3-5). The process comprises: providing a high speed centrifugal finishing apparatus having an outer vessel and at least one inner vessel (Page 7, line 19 – Page 8, line 10), placing the saw blade in the inner vessel (Page 8, line 23 – Page 9, line 4), adding abrasive finishing media into the inner vessel (Page 9, lines 5-8), and rotating the inner vessel at high speed relative to the outer vessel, the high speed rotation causing the abrasive media to surface finish the blades (Page 8, lines 4-22; Page 10, lines 7-9). The process is described in detail in U.S. Patent Nos. 5,140,783, 5,507,685, and 5,848,919 which are incorporated by reference in their entirety (Page 7, lines 16-18; Page 8, lines 16-22).

6. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The grounds of rejection to be reviewed on appeal are as follows:

(a) Rejection of claims 1, 2, 6, 13, 14, and 18 under 35 U.S.C. § 102 as anticipated by U.S. Patent No. 5,802,932 (Vankov, et al.).

(b) Rejection of claims 1, 2, 6, 13, 14, 18, and 19 under 35 U.S.C. § 102 as anticipated by U.S. Patent No. 5,477,616 (Williams, et al.).

(c) Rejection of claims 1, 2, 4, 5, 6, 13, 14, 16, 17, and 18 under 35 U.S.C. § 103 as obvious over Vankov or Williams in view of U.S. Patent No. 5,873,770 (Hashimoto, et al.).

(d) Rejection of claims 3 and 15 under 35 U.S.C. § 103 as obvious over Vankov or Williams in view of Hashimoto, as applied to claims 1 and 13, in further view of U.S. Patent No. 5,555,788 (Gakhar, et al.).

7. ARGUMENT

A. The 35 U.S.C. § 102(b) Rejection of Claims 1, 2, 6, 13, 14, and 18 over Vankov

(i) Examiner's Rejection

The Examiner has rejected claims 1, 2, 6, 13, 14, and 18 under § 102(b) as being anticipated by U.S. Patent No. 5,802,932 (Vankov, et al.). More particularly, in the office action mailed on April 20, 2005, the Examiner has taken the position that because Vankov discloses a blade portion with a plurality of teeth having a surface finish of less than approximately 10 Ra, Vankov therefore "teaches that the high precision surface finishing process inherently reduces residual tensile stress of the saw blade." The Examiner thus attempts to link two properties of such a blade, i.e., a high precision surface finish and a reduced residual tensile stress. However, as discussed more thoroughly below, these two properties are not linked as the Examiner assumes, but exist independently. Thus, the Examiner's rejection of the claims as anticipated by Vankov is based an unsupported assumption.

In support of this proposed link, the Examiner states that Vankov discloses such a "blade portion with a plurality of teeth and two opposed sides which define a blade portion width, having a surface finish less than approximately 10 Ra (col. 5, lines 56-61; col. 6, lines 14-18; col. 10, lines 33-45), having a surface finish which is approximately 6 Ra or less (col. 6, lines 14-18), the sides of the teeth having a surface finish less than 10 Ra and less than 6 Ra (col. 5, line 65 through col. 6, line 3), a cutting edge and teeth having a cutting tips width that are substantially the same as the blade portion width." However, the Examiner provides no citation (nor is one possible) to support the subsequent argument that the surface finish disclosed by Vankov "inherently reduces residual tensile stress" or that Vankov purports to teach or suggest such an assertion.

The Examiner goes on to make the unsupported assertion that the manner by which the "surface finishing process inherently reduces the residual tensile stress of the blade portion [is] by removing part of the cutting edge or sharpening the cutting edge." The Examiner has essentially taken the position that removing part of the material of the cutting edge but leaving the underlying material unchanged, as taught by Vankov (col. 6, lines 5-10; col. 10, lines 39-45), is equivalent to changing the molecular properties of the cutting edge. There is no support for

this assertion. Vankov discloses the use of an electropolishing process specifically as a way of removing material to round the edges or ends of blade teeth (col. 5, lines 17-20; col. 6, lines 39-40), but says nothing regarding any changes to the material structure of remaining blade after electropolishing. In contrast, the present application particularly notes that the claimed process "reduces and/or eliminates embrittlement of the blade" (Page 10, lines 3-4).

The Examiner concludes that the product claimed in the product-by-process claims of the present invention is the same as or obvious from the product taught by Vankov, without substantiating that this is so, and in the face of evidence to the contrary. As will become apparent below, the Examiner's position – that a high precision finish surface has reduced residual stress – is premised on the evidence provided by the Applicant. However, the Examiner misses one critical point. The evidence, including test data and expert affidavits, were based on the specific process recited in the claims, not a completely different electropolishing process.

Finally, the Examiner, citing *In re Thorpe*, 777 F.2d 695, 698, 277 USPQ 964, 966 (Fed. Cir. 1985), takes the position that since the product is anticipated or obvious, "the [product-by-process] claim is unpatentable even though the product of the prior art was made by a different process." However, if a product is structurally different from that which is disclosed in the art, then it cannot be anticipated by the prior art. Such is the case in the present application.

(ii) ***Vankov Does Not Teach a Blade with Reduced Tensile and Therefore Vankov Does Not Anticipate Claims 1, 2, 6, 13, 14, and 18***

The Examiner's rejection is premised, in its entirety, on the erroneous argument that the product produced by the process claimed in the present invention is "the same [as] or obvious from" the product produced by the prior art process used by Vankov. It is not. Applicant has shown the existence of "unobvious difference[s] between the claimed product and the prior art product," so that Applicant readily meets the required burden to overcome a rejection of a product-by-process claim in view of prior art that may appear to be the same or similar. MPEP § 2113. As noted by the Examiner in the April 20, 2005 office action, rejection of a product-by-process claim as anticipated under 35 U.S.C. § 102 is acceptable "when the prior art reasonably appears to be either identical with or only slightly different than a product claimed in [the] product-by-process claim." MPEP § 2113. Conversely, such a rejection is improper when the

claimed product is shown to be a structurally different product, not identical to the prior art product cited against it, and possesses such distinct, advantageous, and non-obvious features as to make it not sufficiently similar to the prior art product. The latter is the factual circumstance that applies to the present invention.

The Examiner has taken the position that because the claimed product and the product of Vankov have a similarly fine surface finish, the underlying material of both products possesses the same structural characteristics and properties. The Examiner presents this position with no factual support in the prior art, repeatedly using the words "inherent" and "inherently" as if to say that, *ipso facto*, a finely polished surface necessarily possesses reduced residual tensile stress. This argument is clearly erroneous, as will be shown by the detailed data presented below.

The product of the present invention and the product of Vankov are not "substantially similar" as the Examiner would argue. The Examiner's unsubstantiated assertions that "the surface finishing process inherently reduces the residual tensile stress," and other like statements, cannot be made true by repetition. This proposition is roundly refuted by proof offered in the various forms of testing data and testimony presented in Appendices A through C. This data was originally filed in the response to office action of May 6, 2004 according to 37 CFR 1.132.

Product-by-Process Claims are Legally Proper

Although the Examiner's § 102/103 rejections in the April 20, 2005 office action purport to follow the required format for product-by-process claim, the Examiner continues to eschew the explicit guidelines set forth in MPEP § 2113 for evaluating product-by-process claims and to ignore the enunciated standard of the Court of Appeals for the Federal Circuit with regard to such claims. In the words of the Examiner, "Applicant's argument that the process-by-product [sic] formulation is proper under MPEP § 2113 that the process produces a product that is structurally different and can not be defined in purely structure [sic] terms is not persuasive." This statement is contrary to the law.

It is well established that "a product-by-process claim, which is a product claim that defines the claimed product in terms of the process by which it is made, is proper." MPEP § 2173.05(p). Although "[p]roduct-by-process claims are not specifically discussed in the patent statute[, t]he practice and governing law have developed in response to the need to enable an

applicant to claim an otherwise patentable product that resists definition by other than the process by which it is made." *In re Thorpe*, 777 F.2d 695, 697 (Fed. Cir. 1985). Such claims have long been recognized as appropriate in the case when "an article of manufacture is a new thing, a useful thing, and embodies invention, and that article cannot be properly defined and discriminated from prior art otherwise than by reference to the process of producing it." *In re Painter*, 1891 C.D. 200, 201, 57 O.G. 999 (Comm'r of Pats. 1891). This so-called Rule of Necessity has been tempered somewhat over time so that now an "applicant can freely choose the product-by-process format, so long as the requirement of definiteness is complied with." DONALD S. CHISUM, PATENTS § 8.05 (2003); *In re Hughes*, 496 F.2d 1216, 1219, 182 USPQ 106 (CCPA 1974).

Further, product-by-process claims do not create a definiteness problem under § 112. "Their scope, if anything, is more definite in reciting a novel product made by a specific process, assuming, of course, that the process is clearly defined." *In re Hughes*, 496 F.2d 1216, 1218, 182 USPQ. 106 (CCPA 1974); *In re Brown*, 459 F.2d 531, 535, 59 CCPA 1036, 1041 (1972) (stating that "a product by process claim[] does not inherently conflict with the second paragraph of 35 U.S.C. § 112").

The Examiner correctly points out, as previously noted, that a rejection may be issued based on § 102/103 upon determining that the prior art discloses a product which reasonably appears to be either identical with or slightly different than a product claimed in a product-by-process claim. The burden then shifts to the applicant to show a non-obvious difference in the product that is produced by the recited process steps. MPEP § 2113, second section heading; *Ex parte Gray*, 10 USPQ 2d 1922, 1925 (BPAI 1989) (stating that an applicant has the "burden of persuasion and [should] ma[k]e some comparison between the two materials to establish unexpected properties for the claimed" product and that the "PTO can require an applicant to prove that the prior art products do not necessarily or inherently possess the characteristics of his claimed product"). Hence, the assertion of an anticipation or obviousness rejection by the Examiner does not end the inquiry. Upon a showing by an applicant that the recited process results in a different product, the applicant has overcome the rejection; there cannot be anticipation when the resulting products are different.

An applicant can overcome a § 102/103 rejection by showing that the process produces a structurally different product, one that "differ[s] unobviously" from the prior art. *In re Brown*, 459 F.2d 531, 536, 59 CCPA 1036, 1043 (1972). "[T]he dispositive issue . . . is whether the claimed [product] exhibits any unexpected properties compared with" the prior art product. *Ex parte Gray*, 10 USPQ 2d 1922, 1924 (BPAI 1989). Numerous cases have applied the *In re Brown* test to find claims patentable once the applicant has been given the opportunity to prove that his product is structurally different as a result of the different process steps.

Of particular interest is *In re Pilkington*, 411 F.2d 1345, 162 USPQ 145 (CCPA 1969). In that case, a claim to a sheet of glass produced by a float process was allowed over prior art plate glass because the float process resulted in a better surface finish, i.e., that the float glass was structurally and physically different. The conclusion that the applicant's "float glass differs from conventional plate glass in certain important respects" rendered the claim patentable. 411 F.2d at 1349. *In re Pilkington* is directly on point and is good law. The facts therein mimic, almost explicitly, the present case. Thus, it is clear that, upon a showing that the process steps recited in the present invention produce a structurally different product, the rejection based solely on a merely superficially similar product cannot stand.

<u>The Recited Process Steps Structurally Alter the Claimed Product</u>

In rejecting the product-by-process claims of the present invention, the Examiner cited *In re Brown*, 459 F.2d 531, 535, 173 USPQ 685, 688 (CCPA 1972) for the proposition that "[a]s a practical matter, the Patent Office is not equipped to manufacture products by the myriad of processes put before it and then obtain prior art products and make physical comparisons therewith." Applicant has asked the Patent Office to do no such thing. Instead, Applicant has provided ample and conclusive evidence establishing the structural differences between the product made by the present process and products made by prior art process used by Vankov.

The current claims recite a cutting tool made through application of a specific set of process steps that result in a low friction, low embrittlement (i.e., increased compressive stress) product. To prove that the process steps result in a different product, Applicant has had testing conducted on both a saw blade processed in accordance with claims 1, 13, and 19, and a saw blade processed using the electropolishing process referred to in Vankov.

Preparation of Test Saw Blades

In Evidence Appendix A is documentary evidence from Tim Valesquez, who is highly experienced in the art of finishing, and who has particular expertise in electropolishing. Mr. Valesquez is the owner of Union Hard Chromium Co., Inc. As outlined in his report, Mr. Valesquez electropolished two standard saw blades that were provided by Applicant. The process used was a conventional electropolishing process, in accord with the process described in Vankov (*see* col. 5, lines 6-10, stating that the blade surface was subjected to a conventional electropolishing process). Thus, saw blades made in accordance with Vankov were used in the testing that is discussed below.

Applicant also made two saw blades using the process recited in claims 1, 13, and 19 of the present invention. These saw blades had a surface finish falling within the recited range set forth in claims 1, 13, and 19. (The process recited in the claims may also be referred to herein, and in some of the attached appendices, as the "MIKRONITE finishing process." The "MIKRONITE finishing process" is the high speed abrasive process recited in the claims and described in the specification of the present application. MIKRONITE is a registered trademark of Mikronite Technologies Group Inc., the assignee of the present application.) Thus, saw blades made in accordance with claims 1, 13, and 19 of the present invention were used in the testing that is discussed below.

Testing by a Saw Smith

One of each of the blades – electropolished and finished by the process of claims 1, 13, and 19 – was taken to David Feinberg. Evidence Appendix B includes a report by Mr. Feinberg outlining his background and the testing that was performed. Mr. Feinberg is the owner of Cutter's Edge, a company which is involved in saw blade processing. Mr. Feinberg has over 29 years of experience in the saw blade processing field. He is what is known in the saw blade industry as a "saw smith," a term that dates back many decades and refers to individuals who are particularly skilled in the nuances of saw blades and their processing. As noted in his report, Mr. Feinberg has inspected and tested various processed blades and is knowledgeable about conventional electropolishing processes, as well as the MIKRONITE finishing process.

Mr. Feinberg conducted several tests of the saw blades for purposes of determining their characteristics. These included visual inspection of the effects of both the claimed processing and the electropolishing on the surface of the blades and the carbide tips and vibrational testing of the blades. Visually, Mr. Feinberg noted that the electropolishing process resulted in etching or deterioration of the carbide tips and, more critically, the bond holding the tips to the plate. Any reduction of the bond between the carbide tips and the blade plate could be disastrous since it could lead to loss of the carbide tips. Not only does that render the saw blade deficient, but the breakage of carbide tips during use can be hazardous.

The vibrational test involved mounting the blades in fixtures and hitting them so as to cause each to resonate at its natural frequency. This test, sometimes referred to as a "ring" test, is informative for two reasons. First, the tone (resonance) of the vibration provides a direct indication of the consistency of the processing. The longer the duration of the vibration (evidenced by the duration of the tone resonating), the more consistent the stress distribution throughout the blade. Second, the different pitch of the resonance indicates a different structural configuration of the saw blade. Much like the tightening of a guitar string changes the stress in the string and thus the resulting tone, the modification of the stresses in a saw blade changes the tone at which the blade resonates.

The testing conducted by Mr. Feinberg indicated a distinct vibrational difference between the electropolished saw blade and the saw blade made using the recited process. As noted by Mr. Feinberg, this is clear evidence that the two products are structurally different from one another. This evidence alone is sufficient to prove that the process steps recited in the claims result in a structurally different product. Thus, this evidence presented by the applicant meets the burden set forth in the MPEP (following such case law as *In re Brown* and *Ex parte Gray*) and overcomes the rejections by the Examiner over Vankov.

Testing by American Stress Technologies, Inc.

In order to further substantiate the difference between the products produced by the claimed process and by other processes, Applicant contracted with American Stress Technologies, Inc. to conduct an X-ray diffraction test of the products. Evidence Appendix C includes a report issued by American Stress Technologies, Inc. ("AST").

AST conducted tests on three different saw blades. The first blade was a standard, unfinished saw blade, identical to the blades used to form the electropolished and MIKRONITE processed blades. The first blade provides a baseline for the other test results. The second blade was the electropolished blade, which is the saw blade made in accordance with the process of Vankov. The third blade was the MIKRONITE processed blade, which is the saw blade made in accordance with claims 1, 13, and 19 of the present application.

X-ray diffraction measurements were taken in both the circumferential and axial directions. X-ray diffraction is a well known mechanism for determining residual stress in a part. The basic theory is that the refraction angle of an X-ray will vary depending on the residual stress in the component. Using established algorithms and equations, an accurate determination of the residual stress can be provided. See, e.g., Prevey, P., "Current Applications of X-Ray Diffraction Residual Stress Measurement," Lambda Research, Development in Materials Characterization Technologies, ASM International, Materials Park, OH, 1996, pp. 103-110. [Evidence Appendix F] Applicant notes that this article was previously cited in a Response filed on May 6, 2004 (see pages 12-13 of the response.) It is not apparent if a copy of the article was submitted at that time. It is submitted herewith not as evidence as to the patentability of the claims but, instead, to provide factual support for the *type* of test (X-rat diffraction) that was conducted in the test reports that were previously entered in this matter. Thus, it is not evidence of patentability, but evidence of a customary test procedure for determining residual stress. It is submitted for the Board's information.

As illustrated by the test results in the report, the electropolished saw blade showed essentially no change in the residual stress compared to an unfinished saw blade. The blades both had a slight tensile residual stress. This is in line with the general theory associated with electropolishing, i.e., that the surface is not mechanically altered. Instead, electropolishing simply removes material from the surface to lessen the height of any peaks of surface non-uniformity. Thus, logically, there should not be any significant change to the residual stress in the part. An electropolished part simply has less material.

The MIKRONITE saw blade, on the other hand, experienced an extremely large drop in residual stress resulting in the generation of compressive residual stress within the part, both in the circumferential and axial directions. Compressive residual stresses are beneficial in saw

blades since they tend to reduce the development of fatigue cracks and assist in the reduction of vibrations (which result in noise).

Accordingly, the test results from AST provide further evidence that saw blades made in accordance with claims 1, 13, and 19 are physically different products than the blades made in accordance with the Vankov electropolishing process. This evidence further proves that the process steps recited in the claims result in a structurally different product. Thus, this evidence presented by Applicant further overcomes the rejections by the Examiner over Vankov.

Based on the foregoing, Applicant respectfully requests that the Board reverse the Examiner's rejection of claims 1, 2, 6, 13, 14, and 18 under 35 U.S.C. § 102(b) over Vankov.

B. The 35 U.S.C. § 102(b) Rejection of Claims 1, 2, 6, 13, 14, 18, and 19 over Williams

(i) Examiner's Rejection

The Examiner has rejected claims 1, 2, 6, 13, 14, 18, and 19 under § 102(b) as being anticipated by U.S. Patent No. 5,477,616 (Williams, et al.). Williams discloses the a knife blade produced by starting with a "blank" having a surface finish "in the range of 0.1 Ra to 2.0 Ra," cutting or grinding one face of a v-shaped edge onto the blank, depositing a coating onto the one ground face of the blank via "carburising or nitriding, chemical or physical vapor deposition, electroplating, plasma arc spraying, or other equivalent process," and cutting or grinding a second face of the v-shaped edge onto the blank, to achieve the desired blade hardness at the cutting edge formed at the juncture of the two ground faces (col. 2, lines 3-8 and lines 51-58).

Williams says nothing about the process of achieving the original finish on the blank other than merely stating that a blank with such a surface finish is used. Therefore, it is impossible to know whether the structural characteristics of the blank material, including the residual tensile stress, are altered in any way by the process used to produce the disclosed surface finish. The only evidence of the structural properties of the blank is that it is preferably made from martensitic stainless steel having a specified carbon and chromium content (col. 2, lines 51-54) and that it is tempered (col. 1, lines 65-66).

Williams also says nothing specifically about the ultimate surface finish of the knife blade, although it can be inferred from Williams' claim 7 that the surface finish of the original blank

remains extant for the portion of the blank that is not ground and coated to form the v-shaped cutting edge. Nevertheless, it is important to note again that Williams discloses no processing to achieve the surface finish of the blank and instead begins with a blank already having the desired surface finish. No finish disclosed or discussed by Williams is obtained by processing done after the v-edge has been ground and coated.

After arguing that Williams teaches a blade with a high precision surface finish, the Examiner, once again, makes the unsupported assertion that "Williams also teaches that the high precision surface finishing process inherently reduces residual tensile stress of the saw blade, since it produces a harder cutting edge for the blade and improves the cutting performance of the blade." The Examiner further asserts, without citation or support, that "Williams' surface finishing process that produces surface roughness less than 10 Ra for the saw blade inherently reduces the residual tensile stress of the saw blade." Neither statement is supported in the disclosure of Williams.

The harder cutting edge of Williams' cutting blade has nothing to do with the surface finish of the blank. Williams' harder cutting edge is the result of a "coating [material] harder than the material of the blade" being applied to the blank, "the actual cutting edge being formed wholly of the harder material" (col. 1, lines 47-50). One side of a v-shaped cutting edge is ground onto the blank, that one side is coated with a harder coating material, and then a second side of the v-shaped cutting edge is ground onto the blank so that the entire cutting edge itself is composed of the harder coating material (col. 2, lines 17-24). Additionally, because Williams discloses absolutely nothing about how the original less than 10 Ra surface finish is achieved on the blank, any assertion about the inherent properties of the blank material due to that surface finish is wholly without foundation.

The Examiner concludes by rejecting the claims under the same product-by-process claim reasoning used with regard to the Vankov reference, i.e., that if the claimed product is the same as or obvious from the prior art product, the claimed product is unpatentable even if made by a different process than the prior art.

(ii) Williams Does Not Teach a Blade with Reduced Tensile Stress and Therefore Williams Does Not Anticipate Claims 1, 2, 6, 13, 14, 18, and 19

The Examiner reads disclosure into Williams that does not exist, explicitly or implicitly. As a basic matter, Williams discloses a knife blade and not a saw blade, and it should be recognized from the outset that the duty to which a knife blade is subjected is substantially different from the duty to which a saw blade is subjected. There is a desirability in saw blades to reduce embrittlement (by reducing residual tensile stresses) in the blades since the blades operate under severe working loading, vibration, high speed movement, frictional abrasion and heat. This is particularly true for a saw blade used in conjunction with a power tool. A less brittle saw blade will last longer and operate more safely, since it is less likely to crack and fail during use. A knife blade is not exposed to working conditions of the same severity, and as such, there would be scant motivation to seek a method to reduce embrittlement of a knife blade compared with a saw blade.

The motivation for having a high precision surface finish on a knife is also less than for a saw blade. A knife typically includes a very sharp edge which is narrower than the body of the knife blade and is capable of slicing the workpiece being cut. Frictional drag of the sides of the knife blade is normally not a significant factor in the efficient use of a knife. In contrast, the cutting teeth or tips of a saw blade must carve a path in the workpiece sufficient for the body of the saw blade to pass. The efficiency of the cutting process is greatly influenced by the frictional contact between the sides of the blade and the workpiece. (Pages 1 and 2 of the present application.) To alleviate this problem, a conventional saw blade (i.e., one not finished by the present process) typically has a cutting edge wider than the blade itself. (Page 2 of the present application). Therefore, the desirability of the low friction features imparted to the saw blade of the present invention are manifest, whereas those same features would be, at most, of minimal significance with regard to a knife blade.

Further, Williams does not teach a cutting blade with a surface processed in a manner that imparts a finish having a roughness of less than 10 Ra and a reduced tensile stress. Instead, Williams teaches the manufacture of a knife blade having a coated cutting edge, wherein the blank from which the blade is made initially has a surface finish preferably in the range of 0.1 Ra

to 2.0 Ra (col. 2, lines 56-58). The origins and pre-processing of the blank to achieve this surface finish are unknown and undisclosed.

The "surface finishing process" disclosed in Williams is not the production of a high precision surface finish, as the Examiner would have it, but involves grinding away part of one side of the blank, depositing a coating layer on top of the ground surface, and then the grinding down part of the other side of the blank to form a v-shaped cutting edge that is composed entirely of the coating layer, in order to achieve a harder cutting than could be made from the uncoated blank material itself. The only portions of the finished blade that may retain a surface finish of between 0.1 Ra and 2.0 Ra are the portions of the original blank that have not been ground and/or coated.

As is illustrated by the AST test data included in Evidence Appendix C and discussed in Section (A)(ii) above, the structure of a blade treated by the process of the present invention, as measured by the residual tensile (or compressive) stress in the blade, is different from that of both an untreated blade and a blade that has been electropolished. It is possible, however, for an untreated blade, an electropolished blade, or a blade treated by some other process (including but not limited to that of the present invention), to have a surface finish of less than 10 Ra or less than 6 Ra. Therefore, surface roughness does not necessarily correlate with reduced residual tensile stress. A highly polished surface finish, without more, is insufficient basis from which to draw any conclusions about the structural properties of the underlying material. Knowing only the surface finish of the blank used to make the Williams blade is inadequate information on which to base a conclusion that the Williams blade shares any structural properties with the blade of the present invention.

Williams' disclosure is devoid of any mention of residual tensile stress in either the blank or the coating. Indeed, the Examiner disregards any effect that the processes of Williams may have on the residual stresses in the blade of Williams. Removal of material by grinding is known in the art to create (induce) further residual tensile stresses in a part. Therefore, it is highly likely that the process steps of grinding one face of a cutting edge into the blank, coating the ground side of the blade cutting edge with a harder material, and then grinding of the second face of the cutting edge to form the cutting tip (col. 3, lines 57-65) may introduce substantial residual tensile stresses into the Williams blade, thus making the blade more brittle than the state of the blade

prior to grinding. Because the surface finish of the blank cited by the Examiner is on the blank prior to the Williams processing, its application would not be capable of relieving any residual tensile stresses introduced into the blade during processing. This is in stark contrast to the process of the present invention, which is applied to a finished saw blade and does relieve residual tensile stresses in the material.

Claim 1 recites a "blade portion having a high precision surface finish which is less than or equal to approximately 10 Ra, and wherein the surface has reduced residual tensile stress." This claim is distinguishable from Williams. Williams makes no mention of the structural properties of the blade, other than to disclose the preferred material of the blank and surface roughness of the blank not ground away or coated to make the blade edge. In addition, because Williams does not indicate how the initial surface finish on the blank is obtained, there is no way to ascertain the structural properties, such as the residual tensile stress, in the blank. The only clue is that Williams restricts the coating step to a temperature low enough that it will not negate the temper of the blank material. The mere fact that the knife is tempered prior to processing, provides no evidence that would suggest that the knife blade of Williams has reduced residual tensile stresses. Most importantly, the processing of Williams introduces residual tensile stresses into the blade as a result of grinding a v-shaped cutting tip into the blade, so that the finished blade of Williams cannot have the same reduced residual stress as the saw blade of the present invention.

The Examiner's rejections rely on assertions for which there is no technical basis. The Examiner correctly points out that the process disclosed by Williams "produces a harder cutting edge for the blade and improves the cutting performance of the blade." However, the Examiner attempts to extrapolate these properties, without any evidence, to support the notion that therefore Williams' process "inherently reduces residual tensile stress of the saw blade." As is shown by Williams itself, this purported connection does not exist. Williams teaches a blade whose edge is hardened by the application of a coating to a blade blank and not by decreasing the residual tensile stress of the underlying blade material. Moreover, the processing Williams does in grinding a v-shaped cutting edge into a blank introduces residual tensile stresses into the underlying blade material. Therefore, the Examiner's reasoning on this point is unsound. For

all of the above stated reasons, claim 1 is believed to be new and non-obvious over Williams, and is therefore not unpatentable over Williams.

Claim 2 recites a blade "wherein the width of the blade portion is substantially the same as the width of the cutting tip," whereas Williams teaches a blade with a "v-shaped cutting edge" that is necessarily narrower than the blade itself. Thus, Williams does not anticipate claim 2. Additionally, claims 2 and 6 are dependent from claim 1. Therefore, without prejudice to the individual merits of claims 2 and 6, refutation of the rejection of claim 1 over Williams is equally effective in showing that claims 2 and 6 are new and non-obvious over Williams.

Claim 13 recites a blade having a plurality of teeth formed thereon, "the sides of the teeth having a high precision surface finish which is less than or equal to approximately 10 Ra, and wherein the surface has reduced residual stress." All of the above stated arguments with regard to claim 1 apply with equal force with regard to claim 13. Moreover, Williams does not disclose a blade with teeth, but rather discloses a blade with a v-shaped cutting edge that may be further ground to include serrations or scallops (col. 3, 4-10 and lines 16-25). As such, Williams does not anticipate claim 13. Therefore, for all of the foregoing reasons, claim 13 is not unpatentable over Williams.

Claim 14 recites a blade "wherein the width of the blade portion is substantially the same as the width of the cutting tips," whereas Williams teaches a blade with a "v-shaped cutting edge" that is necessarily narrower than the blade itself. Additionally, claims 14 and 18 are dependent from claim 13. Therefore, without prejudice to the individual merits of claims 14 and 18, refutation of the rejection of claim 13 over Williams is equally effective in showing that claims 14 and 18 are new and non-obvious over Williams.

Claim 19 recites a blade having a plurality of teeth formed thereon, "the teeth having opposed sides, the teeth having cutting tips attached to the teeth . . ., the sides of the teeth having a high precision surface finish which is less than or equal to approximately 10 Ra, and wherein the surface is formed with a compressive residual stress." All of the above stated arguments with regard to claim 1 apply with equal force with regard to claim 19. Moreover, Williams does not disclose a blade with teeth and does not disclose a blade with cutting tips attached to teeth, but rather discloses a blade with a v-shaped cutting edge that may be further ground to include

serrations or scallops (col. 3, 4-10 and lines 16-25). Therefore, because claim 19 is not anticipated by Williams, it is not unpatentable over Williams.

Based on the foregoing, Applicant respectfully requests that the Board reverse the Examiner's rejection of claims 1, 2, 6, 13, 14, 18, and 19 under 35 U.S.C. § 102(b) over Williams.

C. The 35 U.S.C. § 103 Rejection of Claims 1, 2, 4, 5, 6, 13, 14, 16, 17, and 18 over Vankov or Williams in further view of Hashimoto

(i) __Examiner's Rejection__

The Examiner has rejected claims 1, 2, 4, 5, 6, 13, 14, 16, 17, and 18 under § 103 as obvious over Vankov or Williams in further view of U.S. Patent No. 5,873,770 (Hashimoto).

The Examiner states that "Hashimoto teaches a vibratory finishing process which includes tumbling, rotating, spinning, or centrifugal processes, where one or more workpieces are placed in a container and abrasive medial or abrading elements displace portions of the workpiece during the vibratory finishing process[,]" wherein such workpieces may include a scissor or knife blade. The Examiner argues that "Hashimoto's surface finishing process is the same as the surface finishing process of the instant application [because] the centrifugal process inherently includes inner and outer vessel [sic] such as the centrifugal process taught in Hoffman (5,355,638)" (an earlier patent issued to the present inventor on an apparatus very similar to that used in the present application). Therefore, the Examiner opines that "similar to the finishing process of the instant invention Hashimoto's surface finishing process must reduce the residual tensile stress of the blade portion."

In seeking to combine references to create reach the § 103 rejection, the Examiner acknowledges that although neither Vankov nor Williams "teach[es] a centrifugal finishing apparatus that produces a surface roughness of less than 10 Ra or less than 6 Ra for the blade portion and reduces the residual tensile stress of the blade portion," the use of such an apparatus to produce these effects is "well known in the art such as taught by Hashimoto." Even if this were true, it is not sufficient to make out a prima facie case of obviousness as required in MPEP § 706.02(j) and MPEP § 2142. The Examiner bears the initial burden of providing some suggestion of the desirability of doing what the inventor has done. " '[E]ither the references

must expressly or impliedly suggest the claimed invention or the examiner must present a convincing line of reasoning as to why the artisan would have found the claimed invention to have been obvious in light of the teachings of the references.'" MPEP § 2142, quoting *Ex parte Clapp*, 227 USPQ 972, 973 (BPAI 1985).

(ii) There is No Suggestion or Motivation to Combine Either Vankov or Williams with Hashimoto to Achieve the Present Invention and Therefore Neither Combination Renders Obvious Claims 1, 2, 4, 5, 6, 13, 14, 16, 17, and 18

To sustain a rejection based on prima facie obviousness, "the prior art must suggest the desirability of the claimed invention." MPEP § 2143.01. The level of skill in the art alone is not sufficient to suggest a combination of references, nor is the "mere fact that references can be combined or modified." MPEP § 2143.01.

Hashimoto's Process is Not the Process of the Present Invention

Hashimoto discloses a vibratory process of refining the surface finish on a product to approximately 1 to 5 μin-Ra (col. 5, lines 4-6; Figs. 2-4), wherein the vibratory process includes centrifugal processes (col. 4, line 18). (Note that the figures graph data in μm (micrometers) rather than μin (microinches), with 40 micrometers being approximately equivalent to 1 microinch. As used herein and in the present application, the term "Ra" refers to μin-Ra and not to μm-Ra. Therefore 0.025 μm-Ra in the Hashimoto graphs and specification equals about 1 μin-Ra for purposes of the present discussion.)

The Examiner argues that the vibratory process of Hashimoto inherently reduces the residual tensile stress in the material being processed, based on the notion that "Hashimoto's surface finishing process is the same as the surface finishing process of the instant application" and on evidence presented by Applicant in the response to office action filed on January 20, 2005. This evidence was provided to overcome a rejection of claims 1-6 and 13-19 under 35 U.S.C. 112, first paragraph, by showing that parts processed using the high speed finishing apparatus of the present invention had a reduced residual tensile stress (to the point of having a residual compressive stress) when compared with unprocessed parts. However, the evidence presented by Applicant, included herein as Evidence Appendix D, is specific to the surface

finishing process of the present invention and does not necessarily extend to the generic class of "vibratory" finishing processes that are the subject of Hashimoto. This exhibit was originally filed with the response to office action of January 20, 2005.

Nothing in Hashimoto's disclosure indicates an awareness of the ability, much less the desirability, of imparting a reduction in residual tensile stress to the material being processed. More importantly, the mention by Hashimoto of "centrifugal processes" as one type of the vibratory surface finishing process in the same class of "conventional surface finishing processes" as "barreling, tumbling, rotating, agitating, spinning, [and] shaking" (Hashimoto, col. 4, lines 16-18) strongly indicates that Hashimoto does not contemplate the "high speed precision polishing process used in the present invention" (U.S. Pat. Pub. No. 2002/0078813 A1, para. 44). The surface finishing process of the present invention is not a "conventional surface finishing process" and differs in character from the other processes listed in the same sentence by Hashimoto. The scope of Hashimoto's disclosure covers vibratory finishing processes whereby "the abrading elements or media come into contact with exterior surfaces of the workpieces, thereby effectively displacing portions of the workpiece material from the exterior surface" (Hashimoto, col. 5, lines 27-30). In contrast, the process of the present invention causes impingement of the abrasive elements against the exterior surface of the part "similar to shot peening a part" and sufficient to "produce[] a universal stressing of the surface of the metal. (Page 10 of the present application.)

Therefore, the process of Hashimoto and of the present invention are not the same, nor are they equivalent in either manner or result. Hashimoto teaches moderate abrasion, scouring, or sanding of parts, whereas the present invention teaches a surface finishing process more akin to shot peening due to the high velocity rotation of the centrifugal polishing apparatus. Hashimoto teaches the removal of material from the exterior surface alone, whereas the present invention teaches induction of compressive (or reduced tensile) stresses into the finished part.

It should also be noted that although Hashimoto mentions the possible use of the process disclosed therein to treat knife blades or scissors, no mention is made of saw blades. In view of the discussion in Section (B)(ii) regarding the substantial difference in the use and duty of a saw blade as opposed to a knife blade, this deficiency in Hashimoto as a reference further detracts

from any argument of a suggestion or motivation to combine Hashimoto with other references such as Vankov or Williams which do not themselves contemplate saw blades.

__Vankov in view of Hashimoto__

With regard to the rejections over Vankov in view of Hashimoto, the Examiner's argument is premised both on the equivalence of the Hashimoto vibratory finishing process with the high speed centrifugal polishing process of the present invention and on the substitution of a vibratory polishing process (Hashimoto) for electropolishing (Vankov). First, the Hashimoto process is not equivalent to the polishing process of the present invention, as discussed above. Second, there is no suggestion or motivation in either direction to support this substitution to finish the blade of Vankov. Additionally, there would be no expectation for success in making such a substitution, although there are sound reasons to anticipate that such a substitution would fail to produce the desired result. In fact, Vankov's process would likely no longer be effective for its intended use if this substitution were made.

The surface finishing process of Vankov includes masking off one surface of the product "with adhesive tape" or similar means (col. 6, lines 6-7 and 45-46) prior to subjecting the part to electropolishing. Vankov details the particular advantages of using electropolishing for finishing the exposed surfaces (col. 5, line 63 through col. 6, line 14), and specifically touts the simplicity of this process over "elaborate mechanical polishing processes using polishing wheels" (col. 5, lines 6-7). Vankov makes no intimation that any other polishing process could be used to effect the desired result, and instead focuses on the advantages of the electropolishing method chosen.

There is no evidence that the process of Hashimoto would sharpen the cutting edges of Vankov's blade at the juncture between the masked and unmasked surfaces (col. 6, lines 8-17) to achieve the same result as electropolishing. It is unlikely that the adhesive tape used to mask one surface of the blade would stand up to the abrasive finishing media to which it would be exposed under the Hashimoto process. As such, it is impossible to predict the effect of the Hasimoto process on the masked surface and on the edge at the juncture between the masked and unmasked surfaces, although it is likely that the Hashimoto process, applied to Vankov's blade, would round those edges rather than sharpening them. Therefore, there is no expectation that the

Hasimoto process could successfully be applied as a substitute for electropolishing to produce Vankov's product.

The process disclosed in Hashimoto is directed towards finishing exterior surfaces of a workpiece. The result of this process is to remove directional surface textures and surface irregularities, as well as to obtain an isotropic surface. Additionally, Hashimoto cautions that exposure to a vibratory finishing process for "too long" can result in a degraded profile of the working surface (col. 2, lines 38-40). Hashimoto discloses a method of controlling a vibratory finishing process that may include a wide range of processes such as "barreling, tumbling, rotating, agitating, spinning, shaking or centrifugal processes" but makes no mention or analogy between these and any other type of surface finishing process. There is no evidence that Hashimoto regards the vibratory finishing processes as substitutable or in any way equivalent to an electropolishing process, and indeed Hashimoto never mentions electropolishing.

In sum, because there is no suggestion in Vankov or Hashimoto to combine references, because there is no expectation of success (and even reasonable expectation of failure) from the combination, and because using the Hashimoto process on Vankov's blade would (at least as argued by the Examiner) produce a structurally and physically different blade than intended by Vankov, a combination of these references does not render claims 1 and 13 obvious under § 103. And without prejudice to the individual merits of claims 2, 4, 5, and 6 (dependent from claim 1) and claims 14, 16, 17, and 18 (dependent from claim 13), a showing of non-obviousness as to claims 1 and 13 renders claims 2, 4, 5, 6, 14, 16, 17, and 18 also non-obvious.

Based on the foregoing, Applicant respectfully request that the Board reverse the Examiner's rejection of claims 1, 2, 4, 5, 6, 13, 14, 16, 17, and 18 under 35 U.S.C. § 103 over Vankov in view of Hashimoto. As an aside, as should be evident, the assertion of this rejection by the Examiner is tantamount to an admission that the product disclosed in Vankov alone is not the same as the claimed invention.

Williams in view of Hashimoto

With regard to the rejections over Williams in view of Hashimoto, the Examiner's argument is premised both on the equivalence of the Hashimoto vibratory finishing process with the high speed centrifugal polishing process of the present invention and on the substitution of

the Hashimoto process for an unknown surface preparation method that occurs prior to the processes disclosed in Williams. First, the Hashimoto process is not equivalent to the polishing process of the present invention, as discussed above. Second, there is the lack of any suggestion or motivation in either direction to support a substitution of the Hashimoto process to prepare the blank used by Williams.

To render a claim obvious, the combination of prior art references "must teach or suggest all of the claim limitations." MPEP § 706.02(j); MPEP § 2142. Here, the references do not. First, Williams teaches a knife blade, not a saw blade. Second, Williams teaches a blade that begins as a blank having a fine surface finish that falls with the range of claim 1, which is subsequently subjected to further processing (i.e., grinding) that introduces new residual tensile stresses into the blank. Therefore, any benefit of a reduction in residual tensile stress that could have been introduced by producing the initial finish in the blank is negated by the subsequent grinding operation. Even assuming *arguendo* that Hashimoto's process does reduce the residual stress of the material being processed, a blank first prepared by the method of Hashimoto and then finished into blade by the process of Williams would not possess the same reduced residual tensile stress as a blade whose surface was finished by the Hashimoto process after it was completely mechanically formed. This is because the grinding and coating processes of Williams introduce residual tensile stresses into the material of the blank. Therefore, even if it were known by Williams that the Hashimoto process desirably reduced residual tensile stress, and even if Williams desired to so reduce the residual tensile stress in a knife blade, pre-processing the blank by the method of Hashimoto would not accomplish this result. Stated differently, substitution of Hashimoto's process for the unknown blank pre-finishing process of Williams does not result in a blade having the reduced residual tensile stress characteristics of the present invention.

Further, because Williams' process does not include polishing the blank after grinding the v-shaped cutting edge, there is no motivation whatsoever to apply Hashimoto's finishing process as a final step to Williams' process. Indeed, the application of either Hashimoto's finishing process or the present finishing process to the blade of Williams would negatively impact the hardening coating applied by Williams.

"In order to rely on equivalence [(i.e., substitution of one process for another)] as a rationale supporting an obviousness rejection, the equivalency must be recognized in the prior art, and cannot be based on applicant's disclosure . . . ." MPEP § 2144.06. Neither can equivalency be based on the mere fact that the processes at issue produces a product that is equivalent in one mechanical or structural aspect. MPEP § 2144.06. As previously noted, it is possible for an untreated blade, an electropolished blade, or a blade treated by some other process (including but not limited to those of Hashimoto or of the present invention), to have a surface finish of less than 10 Ra or less than 6 Ra. Also, as previously noted, Hashimoto indicates no awareness of the ability, much less the desirability, to reduce the residual tensile stress of a material by use of the disclosed process. As such, the mere knowledge that the Hashimoto process can produce a surface finish in these ranges is not sufficient to sustain an argument that there is a suggestion or motivation to combine Hashimoto with Williams in order to render the present invention obvious.

The Examiner has asserted that Applicant has used the process of Hashimoto to produce a blade with a finished surface roughness overlapping the range disclosed in Williams, and thus, this combination of references renders Applicant's invention obvious. Applicant disagrees that the process of the present invention finds an equivalent in the disclosure of Hashimoto. Even if the Examiner were correct on this point, it is improper hindsight to argue that because a process discussed in Hashimoto is used to produce a blade having a the surface finish disclosed in Williams, it therefore is obvious to do so. Neither reference expressly or impliedly suggests the claimed invention or substitution of one process for the other. And no other reference has been cited to suggest the motivation to combine the teachings. Therefore, a combination of these references does not render obvious a product having a finish in a range disclosed by Williams but produced by a process purportedly discussed by Hashimoto.

With regard particularly to claims 1, 2, 4, 5, 6, 13, 14, 16, 17, and 18, the difference between a product produced by the present method which has a distinct structural advantage, and the polished blank used as a starting point by Williams about which no structural properties are known, is central to the present invention but would be irrelevant to Williams. According to MPEP § 2113, "[t]he structure implied by the process steps should be considered when assessing the patentability of product-by-process claims over the prior art, especially where . . . the

manufacturing process would be expected to impart distinctive structural characteristics to the final product." This is precisely such a case. The blade produced by the present process has been shown to have a reduced residual tensile stress compared with other similar blades whose surfaces are finished by other processes. Because Williams is not concerned with the residual tensile stress in the blank or blade, there is no reason for Williams to consider beginning with a blank polished by any other process that the unknown one being used. The very lack of mention of the surface finishing method used to prepare the blank in Williams indicates that any structural changes that could be imparted by an alternative method are of no interest to Williams. Therefore, there is clearly no suggestion or motivation in Williams to substitute for the unknown process any other process, much less the process of Hashimoto or the process of the present invention.

Moreover, as previously discussed, Williams discloses a knife blade and not a saw blade. A knife blade is not subjected to the same severity of duty as saw blade. While Applicant has determined the desirability to reduce embrittlement (by reducing residual tensile stresses) in a saw blade, the same is not necessarily true for a knife blade. A saw blade is exposed to severe working loading and forces, vibration, high speed movement, intense frictional abrasion, and heat. A knife is not. There is no motivation to reduce embrittlement with regard to a knife blade, since the operating conditions of a knife blade simply do not demand this feature. Therefore, even if Williams were aware of the process of the present invention and its inherent benefits, there would be no suggestion for Williams to displace the process already in use to prepare the knife blanks disclosed therein.

Evidence of Industry Recognition and Commercial Success

Evidence of such secondary considerations as commercial success and long felt but unsolved needs must be considered under § 103 when evaluating the non-obviousness of an invention. MPEP § 2141; MPEP § 2144.08; *Graham v. John Deere*, 383 U.S. 1, 148 USPQ 459 (1966). In this case, the recognition of the significant benefits of the saw blade of the present invention by a leader in the field of power tool products is a strong indicia of commercial success and the filling of a long felt but unsolved need.

Evidence Appendix E includes a Declaration of Jeffrey Coats, the current President and Chief Executive Office of Mikronite Technologies Group, Inc., the assignee of the present application. As discussed in his Declaration, Mr. Coats describes the testing that DeWalt Power Tools has done related to the saw blade made in accordance with the present invention. DeWalt Power Tools is a world renowned manufacturer of power tool products, including saw blade products. DeWalt has, as part of its decision as to whether to license the technology, conducted extensive testing of saw blades made in accordance with the present invention. The results were such that not only has DeWalt entered into a license with Mikronite Technologies, but it uses its test results as part of its marketing campaign. Specifically, DeWalt markets the fact that the processed edge will last 20% longer (due to the increased compressive residual stress), will run 35% faster (due to the reduced frictional surface and the increased compressive residual stress), and will stay 20% cooler (due to the reduced frictional surface). This exhibit was originally filed with the response to office action of May 6, 2004.

This recognition by DeWalt, a leader in saw blade manufacturing, is direct evidence of industry recognition of the unexpected and commercially important benefits that result in the saw blade made in accordance with the claims.

Based on the foregoing, Applicant respectfully request that the Board reverse the Examiner's rejection of claims 1, 2, 4, 5, 6, 13, 14, 16, 17, and 18 under 35 U.S.C. § 103 over Williams in view of Hashimoto.

D. The 35 U.S.C. § 103 Rejection of Claims 3 and 15 over Vankov or Williams in view of Hashimoto, in further view of Gakhar.

(i) Examiner's Rejection

The Examiner has rejected claims 3 and 15 under § 103 as obvious over Vankov or Williams in view of Hashimoto as applied to claims 1 and 13, in further view of U.S. Patent No. 5,555,788 (Gakhar, et. al).

The Examiner states that Vankov or Williams as modified by Hashimoto teaches features of claims 13 and 15 but "does not expressly teach that the saw blade is a circular saw blade and includes an anti-kickback portion located circumferentially behind each cutting tip and wherein

at least one portion of the anti-kickback portion has a high precision low friction surface finish." Thus, the Examiner cites Gakhar for the features of a circular blade, an anti-kickback portion, and a low friction surface finish on the anti-kickback portion. The Examiner further asserts that "it would have been obvious to one of ordinary skill in the art to perform the surface finishing process as taught by Vankov or Williams and modified by Hashimoto on a similar blade having cutting tips such as a circular saw as taught by Gakhar."

(ii) There is No Suggestion or Motivation to Combine Either Vankov-Hashimoto or Williams-Hashimoto with Gakhar to Achieve the Present Invention and Therefore Neither Combination Renders Obvious Claims 3 and 15

Notwithstanding the lack of motivation to combine Hashimoto with either Vankov or Williams, there is no motivation or suggestion to combine Gakhar with either of these combinations of references. Additionally, the Examiner errs in asserting that Vankov and Williams disclose blades with cutting tips akin to the tips (15) of the present invention and the cutting tips (12) of Gakhar. They do not. Vankov has a cutting edge that is a smooth, sharp juncture between two surfaces, and the cutting action of Vankov occurs by shearing motion between two blades translating with respect to each other, in essentially a scissoring action. Williams has a v-shaped cutting edge that is ground into a blank and subsequently coated, and Williams' blade has no cutting tips or teeth.

Vankov does not intimate any notion of a circular blade or a blade having a kickback portion. Vankov discloses a beard trimmer that shears off hairs protruding in between a pair of blades while moving along the skin surface of a user. In contrast, the saw blade Gakhar or of the present invention cuts into a workpiece, the blade itself being led by a cutting edge, cutting teeth, or cutting tips. The manner of operation of the two is so completely different that there could be no suggestion or desirability to make a beard trimmer with a circular blade like the one of Gakhar. Further, there is no need for an anti-kickback portion on the beard trimmer blade, since no kickback can possibly be experienced in the field of beard trimming. The anti-kickback portion of a circular saw blade such as Gakhar functions by limiting the rate at which the cutting tips or teeth can eat into the workpiece, a problem that is non-existent in beard trimming. Therefore, it is implausible that there would be any motivation to combine the features of the

Gakhar saw blade with the Vankov beard trimmer blade. This is particularly true with regard to the features that Vankov lacks and which would be unnecessary and out of place on Vankov's blade, i.e., the cutting tips, the circular configuration, and the anti-kickback portion.

Williams similarly makes no intimation of a circular blade or a blade having a kickback portion. Williams discloses a conventional straight blade for a knife having a handle (Fig. 1). Such a knife would be manually manipulated by a user to cut a wide variety of objects, but would not be used in conjunction with a power tool, particularly to perform a sawing operation. In contrast, the saw blade of Gakhar and the circular saw blade embodiment of the present invention would typically be used in conjunction with a power tool such as a table saw or a circular saw. Additionally, there is no need for an anti-kickback portion on the knife blade of Williams, since a user of such a knife does not experience kickback. Therefore, it is implausible that there would be any motivation to combine the features of the Gakhar saw blade with the Williams knife blade. This is particularly true with regard to the features that Williams lacks and would be unnecessary and out of place on Williams' blade, i.e., the cutting tips, the circular configuration, and the anti-kickback portion.

Gakhar does not disclose a blade with anti-kickback portions having a low friction high precision surface finish similar to that of the present invention. Instead, Gakhar discloses a blade presumably having the surface finish of a conventional circular saw blade which is then coated with Teflon (col. 1, lines 10-12; col. 6, lines 51-54; claims 3, 4, 5, 6, 11, and 12). Both claims 3 and 15 recite circular saw blades having anti-kickback portions polished to have a low friction surface of less than 10 Ra. Because a coating as applied by Gakhar is not the same as or even similar to the high precision surface finish of the present invention, Gakhar does not suffice to provide the elements missing from Vankov or Williams with respect to claims 3 and 15. Gakhar makes no mention of the surface finish of the underlying blade material prior to coating. Additionally, without prejudice to the individual merits of claims 3 and 15, the showing of the non-obviousness of claims 1 and 13 over Vankov or Williams in view of Hashimoto in Section (C)(ii) above renders claims 3 and 15 also non-obvious.

Based on the foregoing, Applicant respectfully request that the Board reverse the Examiner's rejection of claims 3 and 15 under 35 U.S.C. § 103 over Vankov or Williams in view of Hashimoto in further view of Gakhov.

CONCLUSION

Applicant respectfully submits that the Examiner erred in rejecting claims 1-6 and 13-19 under 35 U.S.C. § 102 and 35 U.S.C. § 103. Neither Vankov nor Williams anticipates every element of the present invention, as is required for a § 102 rejection. Because the product of the present invention has been shown to be structurally different from the products of both Vankov and Williams, rejection of the product-by-process claims of the present invention as anticipated is improper.

Further, Hashimoto cannot be combined with either Vankov or Williams under § 103 to provide the missing elements or structural features, for two reasons. First, Hashimoto does not disclose a process which inherently imparts the same reduction in residual tensile stress as the process of the present invention. Second, even if Hashimoto did disclose such a process, there is no suggestion or motivation in either direction to combine Vankov or Williams with Hashimoto. The Hashimoto process applied to Vankov's blade would render it inoperable for its desired use. Any residual stress benefits imparted by the Hashimoto process to a blank used in the Williams process would be negated by the subsequent grinding steps, and the Hasimoto process applied to Williams' finished blade would impact negatively on the coating applied by Williams.

Finally, Gakhar cannot be further combined with the Vankov-Hashimoto or Williams-Hashimoto reference combinations because Gakhar relates to a completely different field of use and addition of the Gakhar elements would render the Vankov and Williams blades inapt for their desired purposes. The Vankov and Williams blades do not need the circular configuration and anti-kickback portions of Gakhar and there would be no suggestion or motivation to make either of these combinations. Additionally, the low friction surface of Gakhar is a coating on the blade and not a polished surface of the blade material itself.

Applicant requests that the Board reverse the Examiner's rejection of claims 1-6 and 13-19 in the instant application.

Respectfully submitted,

STEVE E. HOFFMAN

BY:

ROBERT E. CANNUSCIO
Registration No. 36,469
Drinker Biddle & Reath LLP
One Logan Square
18th and Cherry Streets
Philadelphia, PA 19103-6996
Tel: 215-988-3303
Fax: 215-988-2757

Attorney for Applicant

8. Claims Appendix

1. An improved saw blade comprising:

a blade portion having two opposed sides which define a blade width; and

a cutting edge formed on the blade portion, the cutting edge having a cutting tip width;

the blade portion having a high precision surface finish which is less than or equal to approximately 10 Ra, and wherein the surface has reduced residual tensile stress which is produced by a process comprising the steps of

providing a high speed centrifugal finishing apparatus having an outer vessel and at least one inner vessel;

placing the saw blade in the inner vessel;

adding abrasive finishing media into the inner vessel; and

rotating the inner vessel at high speed relative to the outer vessel; the high speed rotation causing the abrasive media to surface finish the blades.

2. An improved saw blade according to claim 1 wherein the saw blade is a straight saw blade and wherein the width of the blade portion is substantially the same as the width of the cutting tip.

3. An improved saw blade according to claim 1 wherein the saw blade is a circular saw blade and includes an anti-kickback portion located circumferentially behind each cutting tip, and wherein the side surfaces of the anti-kickback portion are finished with a low friction surface.

4. An improved saw blade according to claim 1 wherein the high precision surface finish is in a range of between approximately 2 Ra and 6 Ra.

5. An improved saw blade according to claim 1 wherein the high precision surface finish is in a range of between approximately 2 Ra and 4 Ra.

6. An improved saw blade according to claim 1 wherein the high precision surface finish is approximately 6 Ra or less.

7. (Canceled)

8. (Canceled)

9. (Canceled)

10. (Canceled)

11. (Canceled)

12. (Canceled)

13. An improved saw blade comprising:

a blade portion having two opposed sides which define the blade portion width; and

a plurality of teeth formed on the blade portion, the teeth having opposed sides, the teeth having cutting tips formed thereon which have a width, the sides of the teeth having a high precision surface finish which is less than or equal to approximately 10 Ra, and wherein the surface has reduced residual tensile stress which is obtained by a process comprising the steps of

providing a high speed centrifugal finishing apparatus having an outer vessel and at least one inner vessel;

placing the saw blade in the inner vessel;

adding abrasive finishing media into the inner vessel; and

rotating the inner vessel at high speed relative to the outer vessel; the high speed rotation causing the abrasive media to surface finish the blades.

14. An improved saw blade according to claim 13 wherein the saw blade is a straight saw blade and wherein the width of the blade portion is substantially the same as the width of the cutting tips.

15. An improved saw blade according to claim 13 wherein the saw blade is a circular saw blade and includes an anti-kickback portion located circumferentially behind each cutting tip, and wherein at least a portion of the anti-kickback portion have a high precision low friction surface finish.

16. An improved saw blade according to claim 13 wherein the high precision surface finish is in a range of between approximately 2 Ra and 6 Ra.

17. An improved saw blade according to claim 13 wherein the high precision surface finish is in a range of between approximately 2 Ra and 4 Ra.

18. An improved saw blade according to claim 13 wherein the high precision surface finish is approximately 6 Ra or less.

19. An improved saw blade comprising:

a blade portion having two opposed sides which define the blade portion width; and

a plurality of teeth formed on the blade portion, the teeth having opposed sides, the teeth having cutting tips attached to the teeth which have a width, the sides of the teeth having a high precision surface finish which is less than or equal to approximately 10 Ra, and wherein the surface is formed with a compressive residual stress through a process comprising the steps of

providing a high speed centrifugal finishing apparatus having an outer vessel and at least one inner vessel;

placing the saw blade in the inner vessel;

adding abrasive finishing media into the inner vessel; and

rotating the inner vessel at high speed relative to the outer vessel; the high speed rotation causing the abrasive media to surface finish the blades.

20. (Canceled)

21. (Canceled)

22. (Canceled)

23. (Canceled)

24. (Canceled)

25. (Canceled)

26. (Canceled)

27. (Canceled)

28. (Canceled)

29. (Canceled)

30. (Canceled)

31. (Canceled)

9. EVIDENCE APPENDICES

Evidence Appendix A:	Valesquez Electropolishing Report Submitted in a Response filed on May 7, 2004. Indicated as entered into case in Office Action mailed July 15, 2004.
Evidence Appendix B:	Feinberg Visual Inspection and Ring Testing Report Submitted in a Response filed on May 7, 2004. Indicated as entered into case in Office Action mailed July 15, 2004.
Evidence Appendix C:	AST X-Ray Diffraction Report Submitted in a Response filed on May 7, 2004. Indicated as entered into case in Office Action mailed July 15, 2004.
Evidence Appendix D:	Coats Declaration re DeWalt Testing and Marketing Submitted in a Response filed on May 7, 2004. Indicated as entered into case in Office Action mailed July 15, 2004.
Evidence Appendix E:	TEC Residual Stress Testing Report Submitted in a Response filed on January 20, 2005. Indicated as entered into case in Office Action mailed April 20, 2005.
Evidence Appendix F:	Prevey, P., "Current Applications of X-Ray Diffraction Residual Stress Measurement," Lambda Research, Development in Materials Characterization Technologies, ASM International, Materials Park, OH, 1996, pp. 103-110. Previously cited in a Response filed on May 6, 2004, which was entered in this application.

10. RELATED PROCEEDINGS APPENDIX

None. There are no related proceedings.

Union Hard Chromium Co., Inc.
136 Market Street, Kenilworth, NJ 07033
Tel. (908) 298-8980 Fax: (908) 298-1966

I am employed by Union Hard Chromium Co. Inc., Which has been involved in electro polishing products for 38 years. I personally have electro polished products for 20 years. I have 20 years of experience in polishing of many different products. I consider myself to be a skilled person in the field of electro polishing. To my knowledge, the process of electro polishing has not varied much over the last decade.

I have been contracted to electro polish two saw blades using conventional electro polishing techniques. I inspected the saw blade products before the electro polishing process. The saw blades appeared to be the same type of blade. I personally conducted the electro polishing process. The electro polish method that I used was current, state-of--the-art, and consistent with the commercially reasonable to apply.

The process was applied correctly. Upon inspecting the resulting product, in my opinion as one skilled in this discipline, I consider the results to be unacceptable both cosmetically and in regard to structural consistency. The resulting products showed poor polishing and heavy smut. In my opinion, no degree of process refinements would have changed the resulting finish. I do not consider electro polishing a suitable polishing option for carbon steel products, such as saw blades, since the resulting finish will not be consistent.

I certify that the foregoing is accurate and true.

Sincerely,

April 27, 2004

Cutter's Edge
Sharpening Service
345 Lakeview Avenue
Clifton, New Jersey 07011
1 (973) 772-6887

To Whom It May Concern:

I have been in the saw and tool processing business professionally since 1975 and currently own and work for Cutter's Edge. In my experience over the last 29 years, I have seen and worked with almost every type of saw device that has been developed. Most of those devices have been worthless. In the industry, I am what is known as a "saw smith."

I have inspected and tested two blades for preparing this report. One blade was processed using the "Mikronite finishing" process. The other blade was electro polished.

I am very familiar with saw blade products that have been processed using the Mikronite finishing process.

Unlike a plated or coated saw blade, the Mikronite finished blades have a smooth, polished, uncoated surface.

One of the problems with blades that are coated or plated with chrome, Teflon or paint is that they can peel or scratch. This defeats the purpose of the coating itself and increases the friction that develops between the blade and the product being cut.

With the Mikronite finishing process the blade is abrasively polished at high speed. There is no coating to peel or scratch. Hence, the blade maintains a smooth surface throughout its life.

I am very familiar with electro plating processes. Generally speaking, in order to electro plate a saw blade you must first chemically treat the base saw blade. This step etches the plate. Also since it is difficult if not impossible economically to mask the carbide tips and the bonds that hold the tips to the plate, these components would also be surface etched too. This can result in chipping of the carbide tips and weakening of the bond that holds the carbide tips to the plate. Thus, in my opinion, electro plating would not be a good process on a saw blade product.

The Mikronite finishing process polishes the saw plate to a fine glass smooth finish. Minimizing the friction and resistance to the material being cut. At the same time the blade is polished, the carbide tip is also polished with the mikronite process. This produces a sharper carbide tip and sharper saw blade.

I conducted some tests comparing a electro polished saw blade against a Mikronite finished saw blade. One of the key test I conducted was a vibration or ring test. Both blades were fixtures and hit so as "ring". The difference in resulting tone is a direct indication in the structural characteristics of the blades. The blades had noticeable differences in tone. In my opinion, these blades are structurally different from one another.

Based on my testing and inspection, my conclusion is that the Mikronite finishing process produces a saw blade with carbide tips that allows the blade to cut faster, with less heat build-up and it lasts longer than any saw blade I am aware of.

I certify that the above information is true and accurate.

Sincerely,

David L. Feinberg

PHIP\378194\1

AST

X-RAY DIFFRACTION SERVICE REPORT

Surface Residual Stress Measurements by XRD on Three Saw Blades

Daniel Manning
Mikronite Technologies, Inc.
511 Washington Avenue
Carlstadt, NJ 07072

DATE COMPLETED: 4/26/04

P.O. NO.: 5164-00042604

DATE RECEIVED: 4/22/2004

SAMPLE ID & DESCRIPTION: Three saw blades with ID's: Unprocessed; Electropolished; and Mikronite Processed. Use same constants used historically with this company's samples: 1008/1018. Measure within area marked with black ink. We will include both radial & circumferential directions.

SCOPE: Perform three surface XRD stress measurements on three saw blades in the marked areas.

RESULTS: As per attached sheets.

MEASUREMENT TECHNIQUES IN COMPLIANCE WITH:

"SAE, 784a - Residual Stress Measurement by X-Ray Diffraction".
{SAE 784a is a retired document no longer supported by SAE}
{Exception: AST uses a modern Modified-Psi diffractometer configuration instead of traditional Omega or Psi.}

Project Manager
Charles H. Flinn ______________________

Project Engineer
Charles H. Flinn ______________________

- The results of this report relate solely to the items tested. This report shall not be reproduced except in full, without the approval of American Stress Technologies.

American Stress Technologies, Inc.
267 Kappa Dr, Pgh, PA 15238 (412)963-0676, fax:(412)963-7552, e-mail: Info@ASTresstech.com, web: www.ASTresstech.com

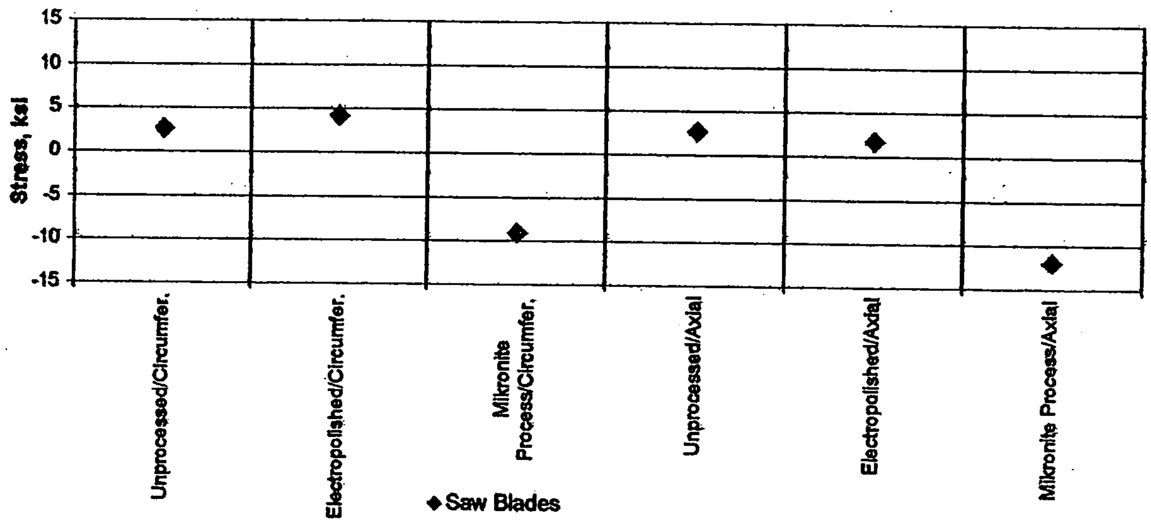
RESIDUAL STRESS RESULTS

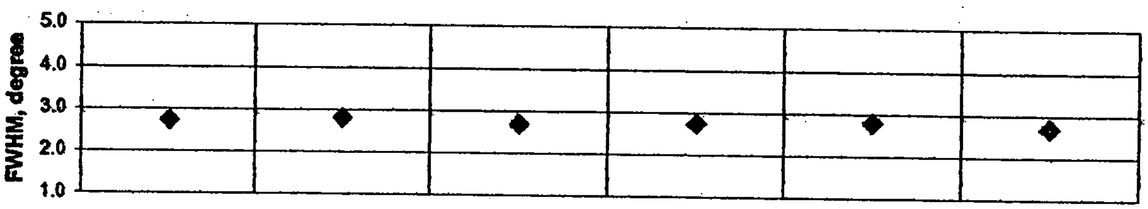
Mikronite Technologies, Inc.
Saw Blades

Radiation (hkl) :	Crka (211)	Spot Size :	3 mm dia. coll.	Exposure Time :	5 seconds
Tilt Settings :	-40-0-40 4/4	Oscillation :	+/- 5 deg psi	Material Removal :	none
Material Constant :	Steel 1008/1018	Modul. E / Poisson v	207000 MPa/.285	Machine/ Soft Ver.	BlueX3000/1.12.1

Location: area near circumference in ink.
Since no direction was requested we measured in 2 directions.

Saw Blades			
ID/Measurement	Stress	Error	FWHM
Direction	ksi	+/-	°
Unprocessed/Circumfer.	2.7	0.4	2.75
Electropolished/Circumfer.	4.2	0.5	2.82
Mikronite Process/Circumfer.	-9.0	0.6	2.69
Unprocessed/Axial	2.7	0.4	2.74
Electropolished/Axial	1.7	0.1	2.79
Mikronite Process/Axial	-12.0	0.5	2.68





FWHM - Full Width at Half Max... measure of peak width.
0 Stress Fe Powder Performance Verfication Check Measured: 0.1 +/-0.4 ksi

PATENT

Attorney Docket No.: 9436-9 (147359)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re:	Patent application of Steve E. Hoffman	
Serial No.:	09/965,162	Group Art Unit: 3724
Filed:	September 27, 2001	Examiner: John Windmuller
For:	IMPROVED SAW BLADE	

DECLARATION OF JEFFREY H. COATS

I, Jeffrey H. Coats, declare as follows:

1. I am President & Chief Executive Officer of Mikronite Technologies Group, Inc., and have been working for Mikronite Technologies Group, Inc. since February 2002.

2. Since August 2001, I have been Managing Director of Maverick Associates LLC, a financial consulting and investment company.

3. From July 1999 to July 2001, I was a Founder and Managing Director of TH Lee Global Internet Managers, L.P., a fund focused on making equity investments in eCommerce and Internet-related companies globally. I am currently a limited partner of the fund.

4. I also served as Managing Director of GE Equity, Inc., a wholly-owned subsidiary of General Electric Capital Corporation, from April 1996 to July 1999. I handled strategic and financial investments in the Internet, eCommerce, media and entertainment, retail and consumer products and services. Many of these investments were made in conjunction with other GE operating subsidiaries, including NBC, GE Lighting and GE Appliances. I have also held various positions, including as Managing Director, of GE Capital Corporate Finance Group, Inc., a wholly-owned subsidiary of General Electric Capital Corporation, from June 1987 to April 1993.

5. I have a B.B.A. in Finance from the University of Georgia and an MBA in International Management from the American Graduate School of International Management.

6. I am knowledgeable about the process and product described and claimed in Application Serial No. 09/965,162. The process relates to surface process finishing process and the product that the process is applied to is a saw blade. I am familiar with testing that has been performed on the saw blade product before and after the process was applied to it.

7. Prior to application of the process, the saw blade product had a conventional rough surface finish. After application of the process, the blade surface was noticeably altered. It had a smooth sheen with a very smooth surface finish.

8. Mikronite Technologies Inc., a subsidiary of the Mikronite Technologies Group, Inc., has licensed the process described in Application Serial No. 09/965,162 to, DeWalt Power Tools, a world renowned manufacturer of power tool products, including saw blade products.

9. DeWalt has performed extensive testing of a saw blade manufactured in accordance with the claimed invention in Application Serial No. 09/965,162. As a result of that testing, DeWalt has begun marketing the saw blade. As part of its marketing, DeWalt promotes the saw blade as having a "Micro Polished Cutting Edge" that "reduces friction and drag." Specifically, the material accompanying the saw blade states that it is "Not a coating. Will not wear off." These relate to the structural, not cosmetic, features of the saw blade. Attached as Exhibit A is the product packaging illustrating the key structural features of the blade that are part of the marketing of the saw blade. This acknowledgement of the structural features of the saw blade from a company that is a leader in the industry and that has been involved making and selling saw blades is clear evidence that the saw blade is distinguishable from existing saw blades.

10. Although the product has just been introduced, there has already been tremendous interest from the industry and the plans are in place for worldwide distribution.

ACKNOWLEDGMENT AND DECLARATION

I declare that all the statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code; and that such willful false statements may jeopardize the validity of this application and any patent issuing thereon.

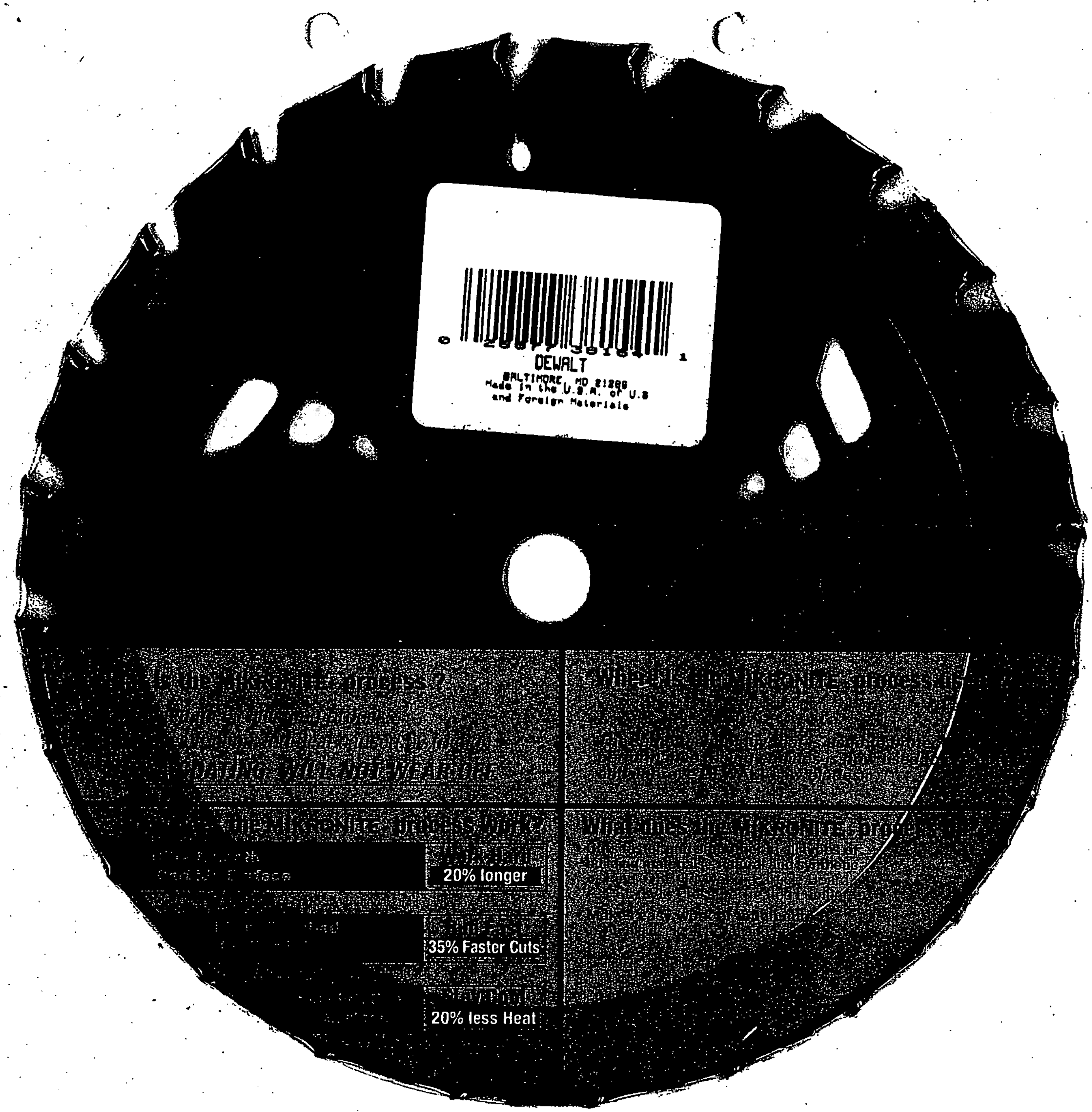
Respectfully submitted,

2-2-04
Date

Jeffrey H. Coats

PHIP\371550\1


Exclusive MIKRONITE® CUTTING EDGE
Ultra-Smooth Carbide Surface
Micro-Polished Cutting Edge
Low Friction Surface
Work Hard.
20% LONGER
Run Fast.
35% FASTER
Stay Cool.
24% COOLER


DEWALT
BALTIMORE, MD 21286
Made in the U.S.A. of U.S
and Foreign Materials
20% longer
35% Faster Cuts
20% less Heat

TEC REPORT NO. R-2004-289
MIKRONITE TECHNOLOGIES
RESIDUAL STRESS SUMMARY
TEC WON NO. 50816

Submitted to:

Mikronite Technologies
511 Washington Ave.
Carlstadt, NJ 07072

Submitted by:

TEC
10737 Lexington Dr.
Knoxville, TN 37932-3294
865-966-5856
Fax: 865-675-1241

Prepared by: Beth Matlock 8-19-04
Senior Materials Engineer

Reviewed by: Beth Matlock 8-19-04
Senior Materials Engineer

August 19, 2004

This Laboratory is accredited by the American Association for Laboratory Accreditation (A2LA) and the results shown in this test report have been determined in accordance with the Laboratory's terms of accreditation unless stated otherwise in the report.

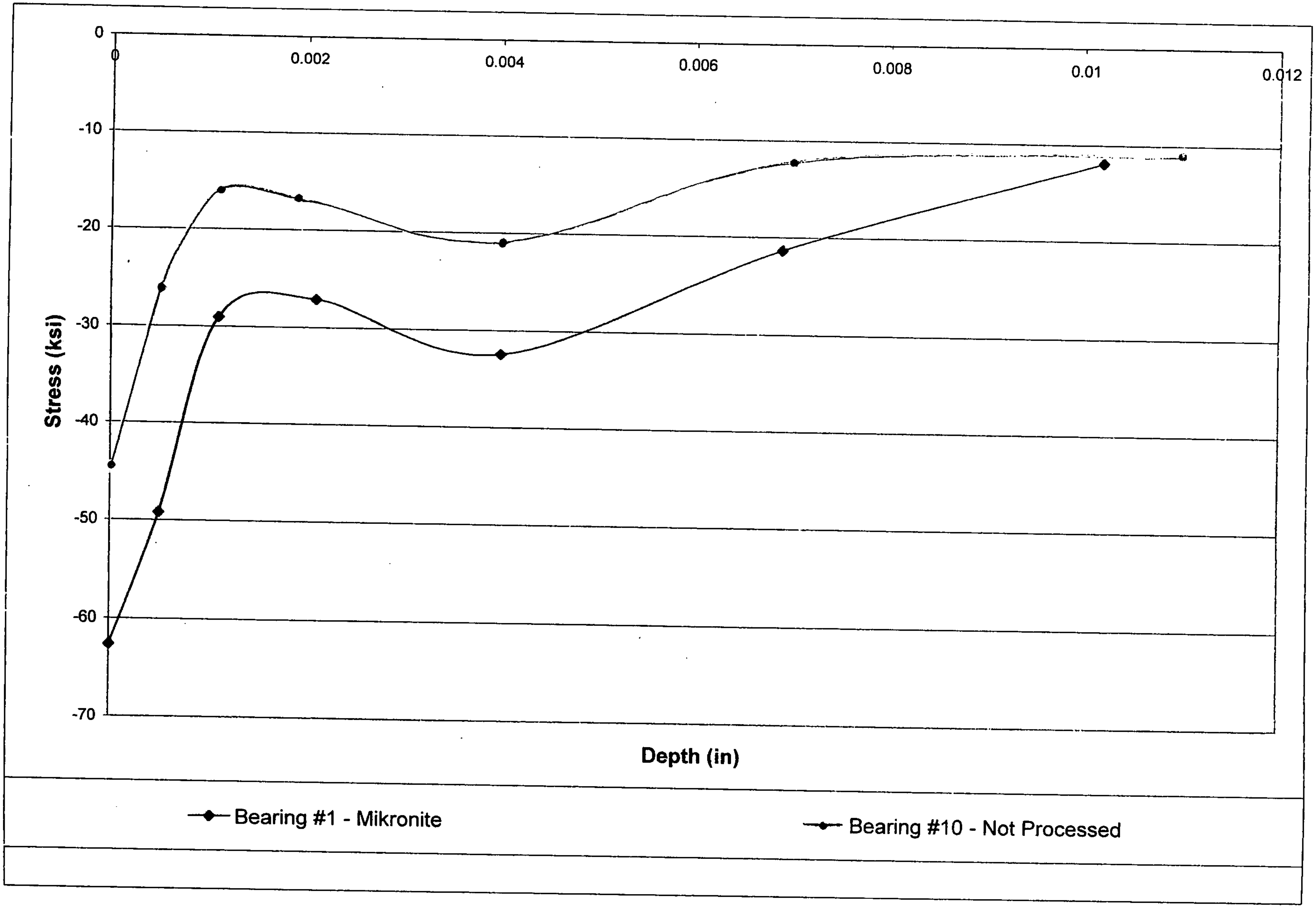
SUMMARY REPORT
MIKRONITE TECHNOLOGIES
RESIDUAL STRESS SUMMARY
Outer Bearing Raceways

Depth, in	Circumferential Residual Stress, ksi As Measured	Corrected for Stress Gradient	Corrected for Layer Removal	Error, ksi
	1. Bearing #1, OD			
0.0000	–56.0	–62.7	–62.7	±2.8
0.0005	–43.7	–49.3	–49.3	±3.1
0.0011	–26.9	–29.2	–29.1	±3.5
0.0021	–27.7	–27.5	–27.2	±2.4
0.0040	–32.7	–32.9	–32.5	±2.3
0.0069	–21.4	–22.1	–21.4	±3.9
0.0102	–12.0	–12.7	–11.9	±1.6
	2. Bearing #5, OD			
0.0000	–67.4	–84.1	–84.1	±3.7
0.0005	–26.1	–36.3	–36.2	±3.3
0.0011	–13.8	–15.4	–15.2	±2.2
0.0019	–20.2	–19.5	–19.3	±1.5
0.0039	–22.1	–22.1	–21.7	±2.9
0.0072	–14.0	–14.7	–14.2	±3.1
0.0105	–0.2	–1.1	–0.5	±2.0
	3. Bearing #7, OD			
0.0000	–59.2	–66.4	–66.4	±2.6
0.0005	–40.9	–46.6	–46.5	±3.5
0.0012	–26.8	–27.7	–27.5	±2.7
0.0020	–36.0	–34.3	–34.1	±2.0
0.0039	–46.5	–46.1	–45.6	±3.4
0.0072	–39.8	–39.7	–38.7	±3.6
0.0099	–48.2	–47.6	–46.3	±3.6

SUMMARY REPORT
MIKRONITE TECHNOLOGIES
RESIDUAL STRESS SUMMARY
Outer Bearing Raceways

Depth, in	Circumferential Residual Stress, ksi			Error, ksi
	As Measured	Corrected for Stress Gradient	Corrected for Layer Removal	
	4. Bearing #8, OD			
0.0000	–83.1	–94.4	–94.4	±2.9
0.0006	–48.8	–53.9	–53.7	±4.3
0.0012	–53.3	–52.9	–52.7	±3.0
0.0019	–51.6	–51.7	–51.3	±2.8
0.0041	–51.8	–51.6	–50.9	±3.9
0.0072	–55.0	–54.6	–53.4	±3.2
0.0100	–64.3	–63.9	–62.1	±2.7
	5. Bearing #9, OD			
0.0000	–14.7	-	-	±3.0
	6. Bearing #10, OD			
0.0000	–37.0	-	-	±2.7

Contents: Summary Report: 4 pages
Appendix: Detailed Explanation of Residual Stress Analysis Data Sheet: 6 pages; Computer-Generated Data Sheets: 68 pages


0
-10
-20
-30
-40
-50
-60
-70
Stress (ksi)
0
0.002
0.004
0.006
0.008
0.01
0.012
Depth (in)
Bearing #1 - Mikronite
Bearing #10 - Not Processed

American Association for Laboratory Accreditation

SCOPE OF ACCREDITATION TO ISO/IEC 17025-1999

TEC MATERIALS TESTING LABORATORY
10737 Lexington Drive
Knoxville, TN 37932-3294
Carol Bailey Phone: 865 966 5856

MECHANICAL

Valid To: February 28, 2006

Certificate Number: 1033-01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following tests on crystalline metals, polymers and ceramics:

Test Technology	Test Methods
Electropolishing for Subsurface Analysis of Residual Stress and Retained Austenite	LP 321
X-ray Diffraction (XRD)	
Residual Stress Measurement and Analysis	ASTM E915, SAE J784a
Retained Austenite Measurement and Analysis	ASTM E975, SAE SP-453

This laboratory offers field-testing. All of the above testing is performed in the field, as well as in the laboratory, both of which are covered by A2LA accreditation:

(A2LA Cert. No. 1033-01) 03/22/2004

5301 Buckeystown Pike, Suite 350 • Frederick, MD 21704-8373 • Phone: 301-644 3248 • Fax: 301-662 2974

TEC REPORT NO. R-2004-304
MIKRONITE TECHNOLOGIES
RESIDUAL STRESS SUMMARY
TEC WON NO. 50908

Submitted to:

Mikronite Technologies
511 Washington Ave.
Carlstadt, NJ 07072

Submitted by:

TEC
10737 Lexington Dr.
Knoxville, TN 37932-3294
865-966-5856
Fax: 865-675-1241

Prepared by: Beth Matlock 8-31-04
Senior Materials Engineer

Reviewed by: Beth Matlock 8-31-04
Senior Materials Engineer

August 31, 2004

This Laboratory is accredited by the American Association for Laboratory Accreditation (A2LA) and the results shown in this test report have been determined in accordance with the Laboratory's terms of accreditation unless stated otherwise in the report.

SUMMARY REPORT
MIKRONITE TECHNOLOGIES
RESIDUAL STRESS SUMMARY
Outer Bearing Raceways

Depth, in	Circumferential Residual Stress, ksi			Error, ksi
	As Measured	Corrected for Stress Gradient	Corrected for Layer Removal	
		1. Raceway #9		
0.0000	–15.0	–9.0	–9.0	±2.7
0.0006	–32.7	–28.0	–28.0	±1.8
0.0011	–40.8	–39.8	–39.7	±3.3
0.0020	–34.8	–35.4	–35.2	±2.3
0.0039	–29.9	–29.6	–29.2	±2.9
0.0073	–40.3	–40.3	–39.5	±3.3
0.0099	–34.9	–35.5	–34.4	±2.4
		2. Raceway #10		
0.0000	–37.3	–44.7	–44.7	±2.5
0.0005	–21.7	–26.3	–26.2	±1.3
0.0011	–15.6	–16.1	–16.0	±2.3
0.0019	–17.4	–16.8	–16.7	±3.5
0.0040	–21.1	–21.2	–21.0	±2.9
0.0070	–12.2	–12.6	–12.1	±2.1
0.0110	–11.3	–11.4	–10.8	±1.6

Contents: Summary Report: 3 pages
Appendix: Detailed Explanation of Residual Stress Analysis Data Sheet: 6 pages; Computer-Generated Data Sheets: 32 pages

TEC REPORT NO. R-2004-286
MIKRONITE TECHNOLOGIES
RESIDUAL STRESS SUMMARY
TEC WON NO. 50797

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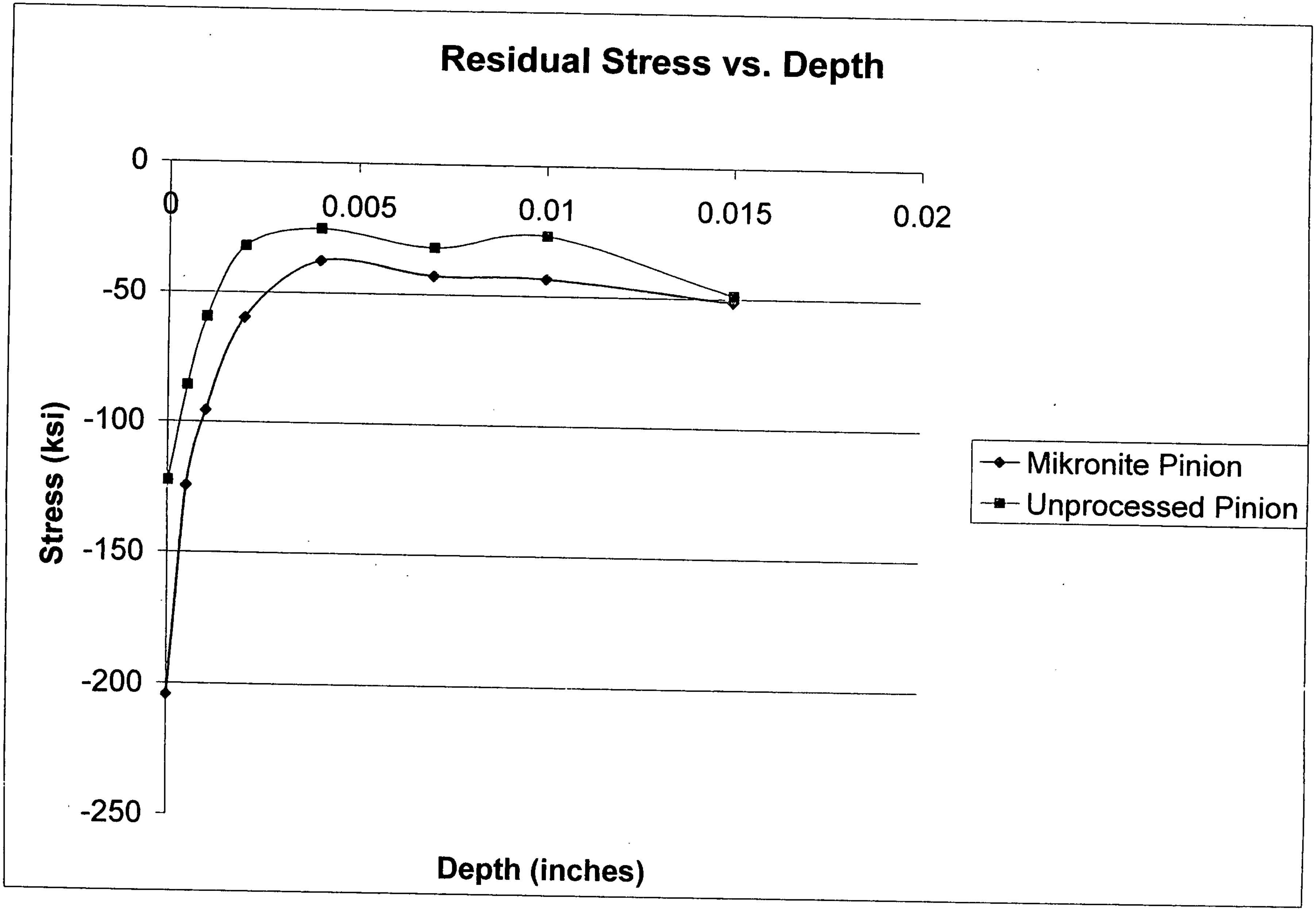
August 13, 2004

This Laboratory is accredited by the American Association for Laboratory Accreditation (A2LA) and the results shown in this test report have been determined in accordance with the Laboratory's terms of accreditation unless stated otherwise in the report.

SUMMARY REPORT
MIKRONITE TECHNOLOGIES
RESIDUAL STRESS SUMMARY
Pinion Gears

Depth, in	Residual Stress, Root to Tip Direction, ksi As Measured	Corrected for Stress Gradient	Corrected for Layer Removal	Error, ksi
	1. Gear RM, Mid-Tooth			
0.0000	−142.3	-	-	±5.8
	2. Gear R, Mid-Tooth			
0.0000	−158.0	-	-	±7.4
	3. Gear M, Mid-Tooth			
0.0000	−176.9	−204.3	−204.3	±4.6
0.0005	−107.8	−125.3	−124.6	±2.0
0.0010	−89.2	−96.8	−95.7	±4.2
0.0020	−57.1	−61.5	−59.8	±3.7
0.0040	−39.6	−40.1	−37.6	±3.0
0.0070	−46.7	−46.3	−42.7	±4.0
0.0100	−48.3	−48.0	−43.3	±3.9
0.0150	−58.5	−58.2	−51.4	±2.9
	4. Gear U, Mid-Tooth			
0.0000	−111.6	−122.7	−122.7	±4.6
0.0005	−75.3	−86.6	−86.2	±3.5
0.0010	−52.4	−60.5	−59.8	±3.2
0.0020	−30.8	−33.4	−32.3	±2.6
0.0040	−27.0	−26.9	−25.3	±2.8
0.0070	−34.6	−34.4	−32.1	±3.7
0.0100	−30.4	−30.0	−27.0	±3.3
0.0150	−54.7	−53.8	−49.1	±2.7

Contents: Summary Report: 3 pages
Appendix: Detailed Explanation of Residual Stress Analysis Data Sheet: 6 pages; Computer-Generated Data Sheets: 40 pages


Residual Stress vs. Depth
0
-50
-100
-150
-200
-250
Stress (ksi)
0
0.005
0.01
0.015
0.02
Depth (inches)
Mikronite Pinion
Unprocessed Pinion

TEC MATERIALS TESTING LABORATORY
CERTIFICATIONS AND CLARIFYING STATEMENTS

Quality System Registration: Certificate Number 03-R0442

This quality system meets the requirements of the ISO 9001:2000 standard for x-ray diffraction testing on materials relating to the automotive, aerospace/aviation, ceramic, and other general manufacturing industries, especially as they relate to process control and quality control; and Government, academic, and commercial research and development laboratories; and related services including electropolishing.

Laboratory Accreditation: Certificate Number 1033.01

The American Association for Laboratory Accreditation (A2LA) has accredited this laboratory for technical competence in the **field of Mechanical Testing**. The Lab's accreditation covers the specific tests and test methods, specifically the ASTM standards, SAE guidelines, and references that are listed on the agreed Scope of Accreditation **(see attached)**. This laboratory meets the requirements of ISO/IEC 17025:1999 "General Requirements for the Competence of Testing and Calibration Laboratories" and any additional program requirements in the identified fields of testing.

Clarifying Statements

The following clarifying statements apply to test results reported herein:

1. These X-ray data are representative of measurements taken of the top few atomic layers at a specific location in a specific direction. Measurement assumptions and metallurgical conditions affect the precision and validity of the data.

2. These test results relate only to the parts tested.

3. This test report and test data shall not be reproduced except in full without the written approval of the Laboratory.

4. The scope of the laboratory's A2LA endorsement is shown above.

5. Products, materials, or other items are in no way approved or endorsed by A2LA without A2LA's explicit approval.

6. Absent a pre-approved sampling procedure, these results do not extend to a sample or samples of a lot or batch from which the sample was drawn.

7. This report does not include or imply an expert opinion as to the serviceability of the sample or batch, or its suitability for a specific purpose.

8. Material removal by electropolishing is accomplished by estimating the time required to remove a certain amount of material. Since electropolishing rates may vary, even through the same sample, targeted depths may inadvertently be exceeded.

February 23, 2004

CURRENT APPLICATIONS OF X-RAY DIFFRACTION RESIDUAL STRESS MEASUREMENT

Paul S. Prevéy
Lambda Research

ABSTRACT

A brief theoretical development of x-ray diffraction residual stress measurement is presented emphasizing practical engineering applications of the plane-stress model, which requires no external standard. Determination of the full stress tensor is briefly described, and alternate mechanical, magnetic, and ultrasonic methods of residual stress measurement are compared.

Sources of error arising in practical application are described. Subsurface measurement is shown to be necessary to accurately determine the stress distributions produced by surface finishing such as machining, grinding, and shot peening, including corrections for penetration of the x-ray beam and layer removal.

Current applications of line broadening for the prediction of material property gradients such as yield strength in machined and shot peened surfaces, and hardness in steels are presented. The development of models for the prediction of thermal, cyclic, and overload residual stress relaxation are described.

X-RAY DIFFRACTION (XRD) STRESS MEASUREMENT can be a powerful tool for failure analysis or process development studies. Quantifying the residual stresses present in a component, which may either accelerate or arrest fatigue or stress corrosion cracking, is frequently crucial to understanding the cause of failure. Successful machining, grinding, shot peening, or heat treatment may hinge upon achieving not only the appropriate surface finish, dimensions, case depth or hardness, but also a residual stress distribution producing the longest component life. The engineer engaged in such studies can benefit by an understanding of the limitations and applications of XRD stress measurement. This paper presents a brief development of the theory and sources of error, and describes recent applications of material property prediction and residual stress relaxation.

Application of XRD stress measurement to practical engineering problems began in the early 1950's. The advent of x-ray diffractometers and the development of the plane-stress residual stress model allowed successful application to hardened steels (1,2). The development of commercial diffractometers and the work of the Fatigue Design and Evaluation Committee of the SAE (3) resulted in widespread application in the automotive and bearing industries in the 1960's. By the late 1970's XRD residual stress measurement was routinely applied in aerospace and nuclear applications involving fatigue and stress corrosion cracking of nickel and titanium alloys, as well as aluminum and steels. Today, measurements are routinely performed in ceramic, intermetallic, composite, and virtually any fine grained crystalline material. A variety of position sensitive detector instruments allow measurement in the field and on massive structures. The theoretical basis has been expanded to allow determination of the full stress tensor, with certain limitations.

Stress is an extrinsic property, and must be calculated from a directly measurable property such as strain, or force and area. The available methods of residual stress "measurement" may be classified into two groups: those that calculate stress from strain assuming linear elasticity, and those that monitor other nonlinear properties.

In x-ray and neutron diffraction methods, the strain is measured in the crystal lattice, and the residual stress producing the strain is calculated, assuming a linear elastic distortion of the crystal lattice. The mechanical linear-elastic methods (dissection techniques) monitor changes in strain caused by sectioning, and are limited by simplifying assumptions concerning the nature of the residual stress field and sample geometry. Center hole drilling is more widely applicable, but is limited to stresses less than nominally 60% of the yield strength (4). All mechanical methods are necessarily destructive, and cannot be directly checked by repeat measurement.
All non-linear-elastic methods, such as ultrasonic and Barkhausen noise are subject to error from preferred

Developments in Materials Characterization Technologies, eds. G. Vander Voort & J. Friel, ASM International, Materials Park, OH, 1996, pp 103-110.

orientation, cold work, and grain size. All require stress-free reference samples, which are otherwise identical to the sample under investigation, and are generally not suitable for laboratory residual stress determination at their current state of development.

XRD residual stress measurement is applicable to fine grained crystalline materials that produce a diffraction peak of suitable intensity, and free of interference in the high back-reflection region for any orientation of the sample surface. Surface measurements are nondestructive. Both the macroscopic residual stresses and line broadening caused by microstresses and damage to the crystals can be determined independently.

Macroscopic stresses, or macrostresses, which extend over distances large relative to the grain size of the material, are the stresses of general interest in design and failure analysis. Macrostresses are tensor quantities, and are determined for a given location and direction by measuring the strain in that direction at a single point. Macrostresses produce uniform distortion of many crystals simultaneously, shifting the angular position of the diffraction peak selected for residual stress measurement.

Microscopic stresses, or microstresses, are treated as scaler properties of the material, related to the degree of cold working or hardness, and result from imperfections in the crystal lattice. Microstresses arise from variations in strain between the "crystallites" bounded by dislocation tangles within the grains, acting over distances less than the dimensions of the crystals. Microstresses vary from point to point within the crystals, producing a range of lattice spacing and broadening of the diffraction peak.

Because the elastic strain changes the mean lattice spacing, only elastic strains are measured by x-ray diffraction. When the elastic limit is exceeded, further strain results in dislocation motion, disruption of the crystal lattice, and an increase in line broadening. Although residual stresses are caused by nonuniform plastic deformation, all residual macrostresses remaining after deformation are necessarily elastic.

The residual stress determined using x-ray diffraction is the arithmetic average stress in a volume of material defined by the irradiated area, which may vary from square centimeters to less than a square millimeter, and the depth of penetration of the x-ray beam. The linear absorption coefficient of the material for the radiation used governs the depth of penetration. For the techniques commonly used for iron, nickel, and aluminum alloys, 50% of the radiation is diffracted from a layer less than 5 μm deep. The shallow depth of penetration and small irradiated area allow measurement of residual stress distributions with spatial and depth resolution exceeding all other methods.

THEORY

A thorough development of the theory of x-ray diffraction residual stress measurement is beyond the scope of this paper. The interested reader is referred to the textbooks and general references (3,5,11,14). As in all diffraction methods, the lattice spacing is calculated from the diffraction angle, 2θ, and the known x-ray wavelength using Bragg's Law. The precision necessary for strain measurement in engineering materials can be achieved using diffraction peaks produced in the high back reflection region, where $2\theta > 120$ deg. The macrostrain is determined from shifts typically less than one degree in the mean position of the diffraction peak. The microstresses and crystallite size reduction caused by plastic deformation are usually expressed simply in terms of diffraction peak angular width, which may range from less than 0.5 deg. for annealed material to over 10 deg. in a hardened steel.

Plane-Stress Elastic Model. Because the x-ray penetration is extremely shallow (< 10 μm), a condition of plane-stress is assumed to exist in the diffracting surface layer. The stress distribution is then described by principal stresses σ_{11}, and σ_{22} in the plane of the surface, with no stress acting perpendicular to the free surface, shown in Figure 1. The normal component σ_{33} and the shear stresses $\sigma_{13} = \sigma_{31}$ and $\sigma_{23} = \sigma_{32}$ acting out of the plane of the sample surface are zero. A strain component perpendicular to the surface, ε_{33}, exists as a result of the Poisson's ratio contractions caused by the two principal stresses.

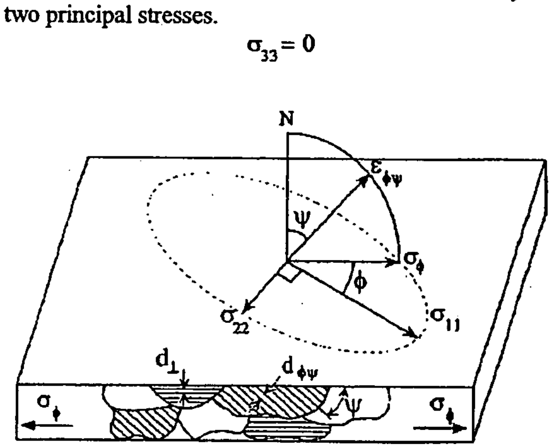


Fig. 1 - Plane stress at a free surface showing the change in lattice spacing with tilt ψ for a uniaxial stress σ_ϕ parallel to one edge.

The strain in the sample surface at an angle ϕ from the principal stress σ_{11} is then given by:

$$\varepsilon_{\phi\psi}=\left(\frac{1+\nu}{E}\right)\sigma_{\phi}\sin^2\psi-\left(\frac{\nu}{E}\right)(\sigma_{11}+\sigma_{22}) \qquad \text{(Eq 1)}$$

Equation 1 relates the surface stress σ_ϕ, in any direction defined by the angle ϕ, to the strain, $\varepsilon_{\phi\psi}$, in the direction (ϕ,ψ) and the principal stresses in the surface. If $d_{\phi\psi}$ is the spacing between the lattice planes measured in the direction defined by ϕ and ψ, the strain can be expressed in terms of changes in the spacing of the crystal lattice:

$$\varepsilon_{\phi\psi}=\frac{\Delta d}{d_0}=\frac{d_{\phi\psi}-d_0}{d_0} \qquad \text{(Eq 2)}$$

where d_0 is the stress-free lattice spacing. Substituting into Eq. 1 and solving for $d_{\phi\psi}$ yields:

$$d_{\phi\psi}=\left[\left(\frac{1+\nu}{E}\right)_{(hkl)}\sigma_\phi d_0\right]\sin^2\psi-\left(\frac{\nu}{E}\right)_{(hkl)}d_0(\sigma_{11}+\sigma_{22})+d_0 \qquad \text{(Eq 3)}$$

where the appropriate elastic constants $(1+\nu)/E_{(hkl)}$ and $(\nu/E)_{(hkl)}$ are now in the crystallographic direction normal to the (hkl) lattice planes in which the strain is measured. Because of elastic anisotropy, the elastic constants in the (hkl) direction commonly vary as much as 40% from the published mechanical values (5,6).

Equation 3 is the fundamental relationship between lattice spacing and the biaxial stresses in the surface of the sample. The lattice spacing $d_{\phi\psi}$, is a linear function of $\sin^2\psi$. Figure 2 shows the variation of d(311) with $\sin^2\psi$, for ψ ranging from 0 to 45° for shot peened 5056-O aluminum having a surface stress of -148 MPa (-21.5 ksi).

The intercept of the plot at $\sin^2\psi = 0$ equals the unstressed lattice spacing, d_0, minus the Poisson's ratio contraction caused by the sum of the principal stresses:

$$d_{\phi 0}=d_0-\left(\frac{\nu}{E}\right)_{(hkl)}d_0(\sigma_{11}+\sigma_{22})=d_0\left[1-\left(\frac{\nu}{E}\right)_{(hkl)}(\sigma_{11}+\sigma_{22})\right] \qquad \text{(Eq 4)}$$

The slope of the plot is:

$$\frac{\partial d_{\phi\psi}}{\partial \sin^2\psi}=\left(\frac{1+\nu}{E}\right)_{(hkl)}\sigma_\phi d_0 \qquad \text{(Eq 5)}$$

which can be solved for the stress σ_ϕ:

$$\sigma_\phi=\left(\frac{E}{1+\nu}\right)_{(hkl)}\frac{1}{d_0}\left(\frac{\partial d_{\phi\psi}}{\partial \sin^2\psi}\right) \qquad \text{(Eq 6)}$$

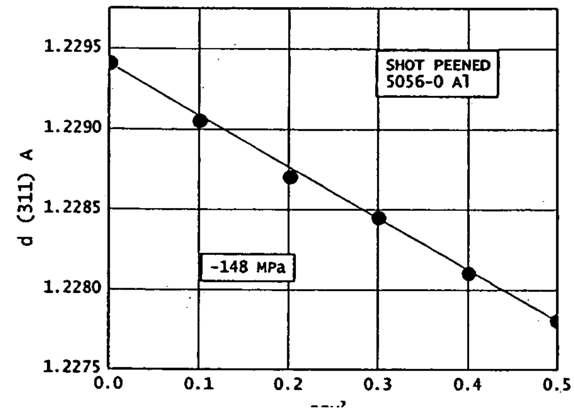


Fig. 2 - Linear dependence of d (311) upon $\mathrm{Sin}^2\psi$ for shot peened 5056-0 aluminum. Ref. (14)

The x-ray elastic constants can be determined empirically (6), but the unstressed lattice spacing, d_0, is generally unknown. However, because $E \gg (\sigma_{11}+\sigma_{22})$, the value of $d_{\phi 0}$ from Eq. 4 differs from d_0 by not more than ± 0.1%, and σ_ϕ may be approximated to this accuracy by substituting $d_{\phi 0}$ for d_0 in Eq. 6. The method then becomes a differential technique, and no stress-free reference standards are required to determine d_0 for the plane-stress model. All of the common variations of x-ray diffraction residual stress measurement, the "single-angle", "two-angle", and "$\sin^2\psi$" techniques, assume plane-stress at the sample surface, and are based on the fundamental relationship between lattice spacing and stress given in Eq. 3.

Stress Tensor Determination. An expression for the lattice spacing can be formulated as a function of ϕ and ψ, for the general case, assuming stresses exist normal to the surface[7]. Nonlinearities producing separation of the $+\psi$ and $-\psi$ data in the form of elliptical curvature of the d-$\sin^2\psi$ plots termed "ψ splitting" are occasionally observed at the surface of ground hardened steels, and are attributable to shear stresses acting normal to the surface[8]. Determination of the full stress tensor has been the focus of most academic research into XRD stress measurement over the last decade, and is necessary in all neutron diffraction applications because of the deep penetration into the sample.

In principle, the full stress tensor can be determined (7, 8). However, unlike the plane-stress model, the stress-free lattice spacing, d_o, must be known independently to the accuracy required for strain measurement (1 part in

10^5) in order to calculate the three normal stress components, σ_{11}, σ_{22}, and σ_{33}. Errors in the normal stress components, which are of primary interest, are proportional to the difference between the value of d_0 assumed and $d_{\phi 0}$. Large errors in both magnitude and sign of the three normal stress components can easily arise from errors in d_0. In most practical applications, such as the surfaces generated by machining, grinding, or hardening, the lattice spacing varies as a result of plastic deformation or heat treatment, precluding independent determination of the unstressed lattice spacing with sufficient precision (9-11). Further, other sources of nonlinearities in d-$\sin^2\psi$ plots such as subsurface stress gradients, instrument misalignment, and failure of the diffraction peak location method must first be eliminated (12,13). The full stress tensor method is therefore limited primarily to research applications.

SOURCES OF ERROR

Because XRD residual stress determination requires precision in the measurement of the angular position of diffraction peak on the order of 1 part in 10^5, many sources of error must be controlled. A thorough discussion of error is beyond the scope of this paper and have been addressed (3,5,11). The sources of error of primary importance in engineering applications may be placed in three categories: sample dependent errors, analytical errors, and instrumental errors.

Sample dependent errors may arise from an excessively coarse grain size, severe texture, or interference of the sample geometry with the x-ray beam. Both surface and subsurface stress gradients are common in machining and grinding, and may cause errors as high as 500 MPa, even altering the sign of the surface stress. Corrections can be made for penetration of the x-ray beam into the subsurface stress gradient using electropolishing to remove layers in fine increments on the order of 5-10 μm (3,1).

Electropolishing for subsurface measurement will cause stress relaxation in the layers exposed. If the stresses in the layers removed are high and the rigidity of the sample is low, the relaxation can be on the order of hundreds of MPa. For simple geometries and stress fields, closed form solutions are available (15). Recently, finite element corrections have been applied to arbitrary geometries (16).

Analytical errors may arise from the validity of the stress model assumed, the use of inaccurate elastic constants, or the method of diffraction peak location. Diffraction peaks several degrees wide must be precisely located within 0.01 deg. Various methods have been developed, but the fitting of Pearson VII functions to separate the $K\alpha$ doublet and allow for peak defocusing caused by the change in ψ angle and line broadening as layers are removed in subsurface measurement is superior (12,13). X-ray elastic constants may be determined empirically to ASTM E1426 to an accuracy on the order of ±1% in four-point bending (6).

Instrumental errors arise from the misalignment of the diffraction apparatus or displacement of the specimen. Sample displacement from the center of the goniometer is the primary instrumental error. Divergence of the x-ray beam and sample displacement can cause "ψ splitting" which is indistinguishable in practice from the presence of sheer stresses, σ_{13} and σ_{23}, acting out of the surface. ASTM E915 provides a simple procedure using a zero stress powder to verify the instrument alignment, except for the accuracy of the ψ rotation.

SUBSURFACE MEASUREMENT

X-ray diffraction residual stress measurements are nondestructive. Attempts have been made since the 1960's to use nondestructive XRD residual stress measurement for process control, with limited success. The difficulty arises for two fundamental reasons.

First, surface residual stresses simply are not reliably representative of either the processes by which they were produced, or the stresses below the surface (17). Grinding and shot peening will commonly produce nearly identical levels of surface compression. Complete ranges of shot peening intensities will often produce virtually identical surface stresses with large differences in the depth of the compressive layer. Many surface finishing processes like tumbling, wire brushing, sand blasting, etc. will produce nearly identical surface compression which may mask subsurface tensile stresses due to welding, prior grinding, etc. Further, nondestructive surface measurements can not be corrected for potentially large errors due to penetration of the x-ray beam into a stress gradient.

Second, extensive studies have demonstrated that the subsurface peak residual stress rather than the surface residual stress generally governs fatigue life (18). The surface residual stress produced by turning, milling and grinding of steels, nickel, titanium, and aluminum alloys has been found to be the most variable and least characteristic of the machining process. The subsurface peak stress, either tensile or compressive, correlates with both room and elevated temperature fatigue behavior in extensive studies of surface integrity. The subsurface residual stress distribution must generally be obtained to adequately characterize a manufacturing process.

PROPERTY PREDICTION FROM LINE BROADENING

The breadth of the diffraction peak used for residual stress measurement increases as materials are cold worked, or as a result of phase transformations such as hardening of martensitic steels. The broadening is primarily the result of two related phenomena: a reduction of the "crystallite" or coherent diffracting domain size, and an increase in the range of microstrain. As a material is cold worked, or strained as a result of phase transformations, the perfect crystalline regions between dislocation tangles become smaller. When these regions are reduced to less than nominally 0.1μm, the diffraction peak breadth increases with further reduction. The microstrain in each crystallite will vary about the mean value for the aggregate of such regions making up the polycrystalline body. This range of microstrain results in variation in lattice spacing of the diffracting crystallites, and increased line broadening. Other imperfections such as stacking faults and point defects also contribute to the peak breadth.

The relative contributions of crystallite size and microstrain to the integral breadth can be separated by the Warren-Averbach method (19). However, the separation is of little practical use in engineering applications, requires extensive data collection, and is subject to variations in interpretation. The measured peak breadth, even without correction for instrumental broadening, can be related directly to material properties of practical engineering interest such as the alteration of yield strength in cold worked alloys, and hardness in martensitic steels.

The hardness in martensitic steels can be measured simultaneously with residual stress with depth resolution on the order of the 5 μm penetration depth of the x-ray beam. The high depth resolution allows detection of thin work softened layers produced by deformation at the surface of critical components such as gears and bearings. An empirical relationship between the (211) peak breadth and Rockwell C hardness for SAE 1552 steel is shown in Figure 3 (16). The hardness calculated from peak broadening is compared to mechanical microhardness measurements at an adjacent location on an induction hardened gear tooth in Figure 4. The high resolution of the x-ray diffraction technique allows a clear definition of the hardness gradient through the case-core interface.

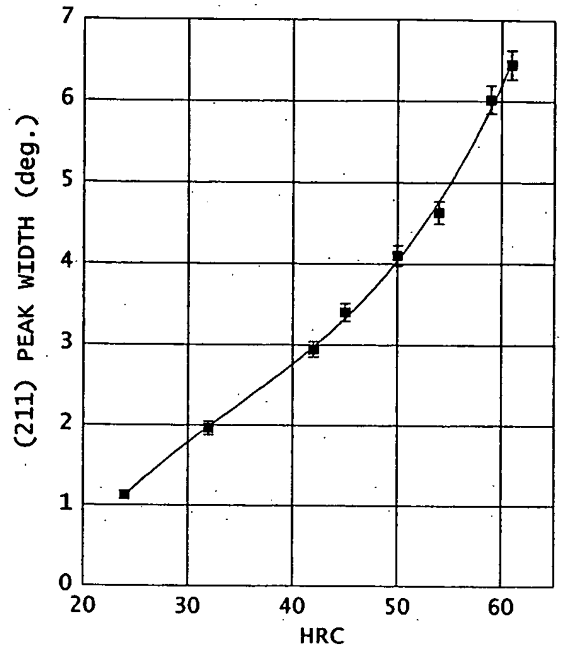


Fig. 3 - Dependence of (211) peak half-width on hardness for SAE 1552 steel. Data points are an average of five measurements using CrKα, peak at 2θ = 156 deg. Ref. (16)

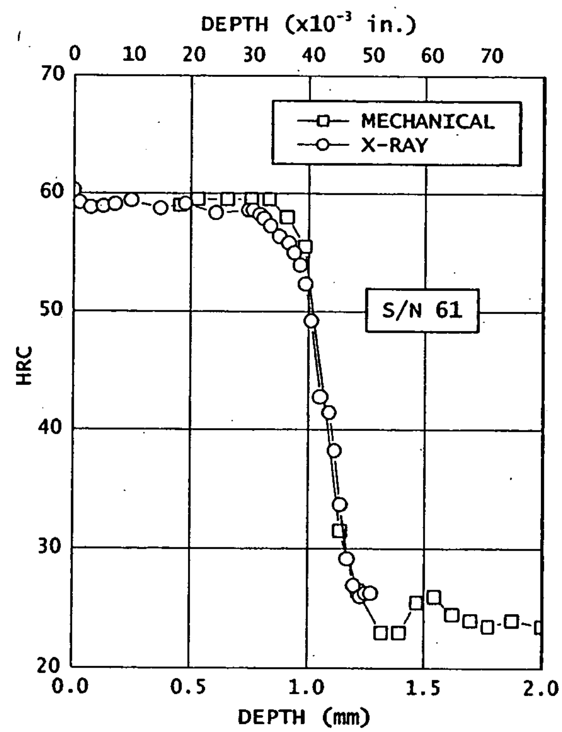


Fig. 4 - Comparison of mechanical (Vickens 500g) and XRD hardness measured at adjacent locations on an induction hardened SAE 1552 steel gear tooth. Ref. (16)

The degree to which materials have been cold worked can be estimated from the peak breadth. If "cold work" is defined as the true plastic strain, a true stress-strain curve can then be used to estimate the resulting change in yield strength (20,21). An example of the relationship between the (420) diffraction peak width and the percent cold work (true plastic strain) for the nickel-base super alloy Rene 95 is shown in Figure 5. The results indicate the accumulated peak breadth is independent of the mode of deformation, and is additive for combined deformation, provided true plastic strain is taken as the measure of cold working.

The complex distribution of yield strength developed by weld shrinkage in previously reamed Inconel 600 sleeve is shown in Figure 6 (22). The line broadening data, converted to percent cold work and then yield strength, reveal a complex layer of highly cold worked surface material extending to a depth of 0.25mm in the reamed area adjacent to the heat affected zone. The plastic deformation caused by weld shrinkage extends 25mm to either side of the weld. The material is only fully annealed well beneath the reamed surface in the heat affected zone. Stress corrosion cracks were associated with peak tensile stresses occurring just at the edge of the highly cold worked reamed area. Note that the yield strength of the deformed surface layers after cold working exceeds twice bulk yield of the alloy.

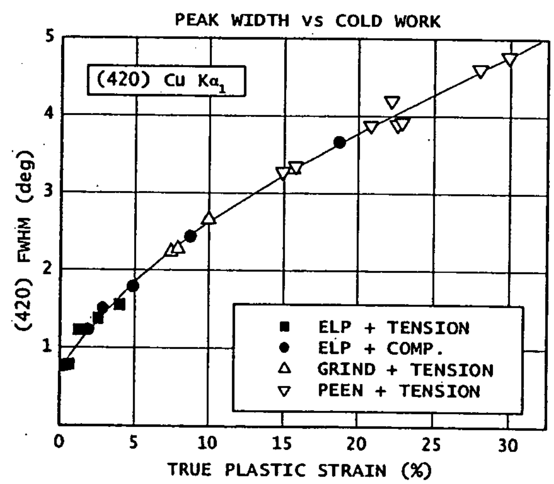


Fig. 5 - Dependence of the (420) $K\alpha_1$ peak width on cold work (true plastic strain) showing independence of the mode of deformation and accumulation. Ref. (20)

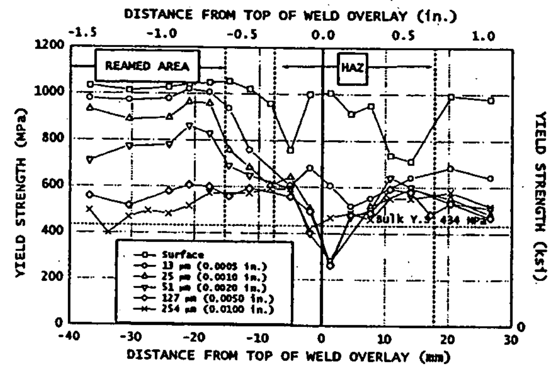


Fig. 6 - Yield strength distribution calculated from peak breadth on the inside surface of Inconel 600 offer reaming and welding (see text). Ref. (22)

MODELING OF RESIDUAL STRESS RELAXATION

The relaxation of residual stress during cyclic loading or at elevated temperature has been reported for decades, and has been reviewed (23). Recently, O. Vöhringer and coworkers (24,25) have developed models for the prediction of residual stress relaxation as functions of time and temperature, single cycle overload, and cyclic loading which promise to be powerful tools for failure analysis.

An Avrami approach is used to describe the fraction of residual stress remaining as a function of time and temperature in terms of an activation energy and to other material constants. The material dependent constants are developed from measurements of the isothermal stress relaxation as functions of time. The predicted and measured stress relaxation at the surface of shot peened AISI 4140 steel, using an incremental relaxation approach, is shown in Figure 7. The thermal relaxation model promises prediction of the retention of compressive residual stresses from shot peening in high temperature applications such as high performance gearing and turbine engine components for both failure analysis and design.

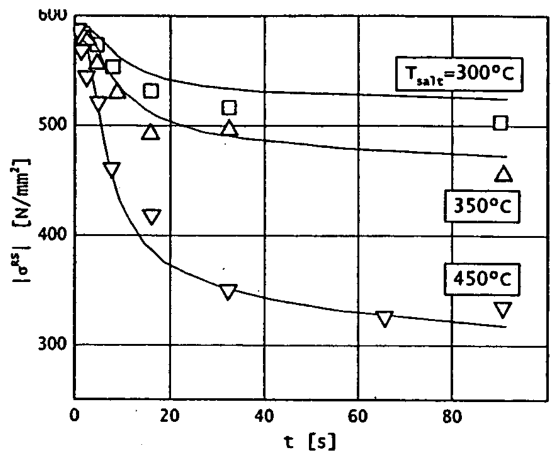


Fig. 7 - Measured residual macro-stress after short time annealing in salt baths of different temperatures and relaxation curves modeled using the numerical stress-transient method based on an Avrami approach. Ref. (25)

Momentary overload is commonly observed to upset and alter the state of residual stresses. Vöhringer has developed a model allowing prediction of the change in residual stress at the surface of a component as a result of plastic deformation. The residual stress and yield strength of the material in the current state and in each layer beneath the surface is incorporated into a finite element model allowing prediction of changes in surface residual stress. An example showing the change in the surface axial residual stress on 4140 shot peened steel in different heat treatments is shown in Figure 8. The model allows prediction of residual stress redistribution by subsequent deformation as in split-sleeve cold-expansion of reamed holes, overload of turbine disk bores at high RPM, and compressive overloading of shot peened components.

Cyclic loading causes residual stress relaxation for alternating stresses significantly above the endurance limit. Vöhringer has proposed a model describing the fraction of the initial residual stress remaining on the surface of a part exposed to cyclic loading as a linear function of log N, where the slope and intercept can be described by material dependent constants, which depend upon the stress amplitude. The model has been applied to both fully reversed bending and axial loading fatigue. The relaxation of surface axial residual stress in shot peened 4140 steel as a function of cycles is shown in Figure 9. After redistribution of stress on initial loading, the surface stress follows a linear reduction with log N, until near failure.

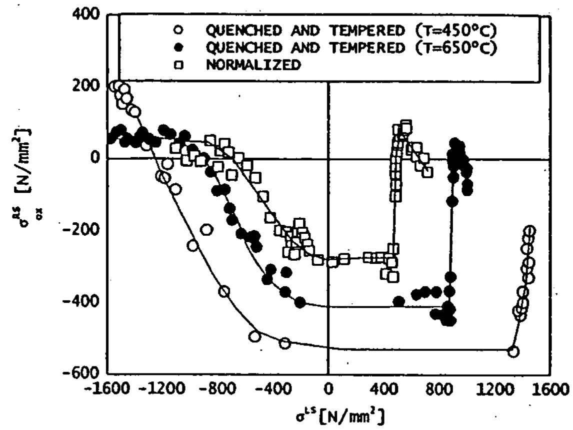


Fig. 8 - Axial macro-residual stress in differently heat treated and shot peened samples as a function of the quasi-static loading stress. Ref. (25)

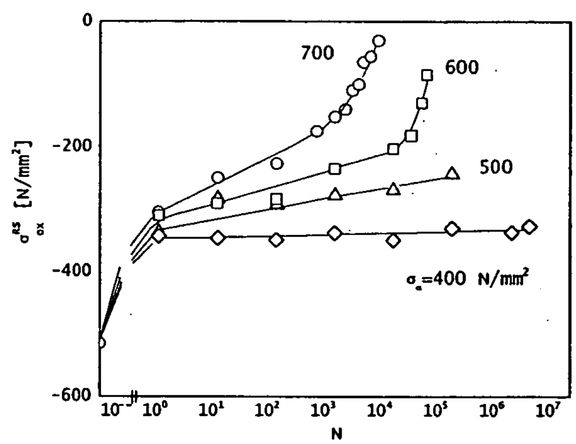


Fig. 9 - Axial macro-residual stress of quenched and tempered samples as a function of the number of loading cycles for various applied stress amplitudes. Ref (25)

In failure analysis, the surface residual stress could be compared to areas of the specimen which were in a comparable state of residual stress prior to cyclic loading in order to estimate either the effective cyclic load or the number of cycles of exposure, if the other is known. Applications include prediction of relaxation of residual stresses under known cyclic loading in design and failure analysis.

CONCLUSIONS

A brief theoretical development and discussion of sources of error shows that the plane-stress model of x-ray diffraction residual stress measurement is the practical approach for engineering applications such as failure analysis and process development. Nondestructive surface residual stress measurements are inadequate for most applications because of errors inherent in uncorrected surface measurements, lack of correlation between surface stresses and the processes which produce them, and the need to know the subsurface peak residual stress to determine the effect on fatigue life.

The diffraction peak width obtained during residual stress measurement can be used to predict material properties such as hardness, percent cold work, and yield strength with high spatial and depth resolution. Current applications include detection of surface deformation producing softening of steels, measuring case depth with stress in induction hardening and increases in yield strength of machined surfaces of work hardenable alloys.

Recent developments in the prediction of residual stress relaxation using x-ray diffraction data have been successfully applied to predict thermal, cyclic, and single cycle upset relaxation of shot peened steels, and promise to become increasingly important tools in design, failure analysis, and process development studies.

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